Union Calendar No. 354

House Report 98–621

STRUCTURAL FAILURES IN PUBLIC FACILITIES

REPORT

BY THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

together with

MINORITY VIEWS

MARCH 15, 1984.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

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U.S. GOVERNMENT PRINTING OFFICE

32-130 O WASHINGTON: 1984

H703-2

LETTER OF SUBMITTAL

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., March 15, 1984.

Hon. THOMAS P. O'NEILL, Jr.,
The Speaker, U.S. House of Representatives,
Washington, D.C.

DEAR MR. SPEAKER: By direction of the Committee on Science and Technology, I submit herewith the committee's report titled, "Structural Failures in Public Facilities" to the 98th Congress. The committee's report is based on an investigative study made by the Subcommitteee on Investigations and Oversight in cooperation with the full committee.

Sincerely,

DON FUQUA, *Chairman.*

LETTER OF TRANSMITTAL

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., February 22, 1984.

Hon. DON FUQUA, *Chairman,*
Committee on Science and Technology,
U.S. House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am pleased to transmit to you a report prepared by the Investigations and Oversight Subcommittee entitled, "Structural Failures in Public Facilities".

The report discusses the findings and recommendations from the Subcommittee's extensive investigation of structural failures in public buildings, dams, and bridges in the United States and draws upon Subcommittee hearings held in August 1982, a survey of the construction industry conducted by the Subcommittee, and the Subcommittee's ongoing review.

The review was undertaken by the Subcommittee because of a concern about the apparent increase in the number of structural failures reported in the media, failures such as that which took place at the Hyatt Regency Hotel in Kansas City, Missouri, in July 1981 and the Hartford Civic Center in Hartford, Connecticut in January 1978.

The Subcommittee did not seek to assess blame in the case of any particular failure, but rather to identify common problems associated with such failures, the elimination of which could decrease the number of failures. The Subcommittee's review identified six significant factors (and several factors of lesser importance) which, in the opinion of the Subcommittee, contributed most significantly to the occurrence of a structural failure. The six factors are:

(1) communications and organization in the construction industry;
(2) inspection of construction by the structural engineer;
(3) general quality of design;
(4) structural connection design details and shop drawings;
(5) selection of architects and engineers; and
(6) timely dissemination of technical data.

In general, the Subcommittee recommendations are designed to institute checks in the building process on the creation of errors that lead to structural failures. The Subcommittee has recommended a variety of actions that the building industry and professional societies can undertake without the necessity of government action, steps such as the establishment of peer review procedures, development of guidelines, and institution of quality control criteria. The Subcommittee also recommended certain actions by state and local governments.

The principal recommendation addressed to the Federal Government calls for the creation, within the National Bureau of Standards, of a national investigative body to obtain and disseminate information on structural failures. This body would be modeled on the widely respected and successful National Transportation Safety Board and represent a reorganization and small enhancement of some of the activities already performed by the National Bureau of Standards. Combined with the cooperative efforts of private industry, the Subcommittee's recommendations could help prevent the causes of many structural failures.

I would like to express my appreciation to the many people in the design, fabrication, and construction industries, who are identified in the report and who cooperated and assisted the Subcommittee staff in developing the hearings, questionnaire, and report, and to Ronald Williams, Technical Consultant, who assisted the Subcommittee staff in preparation of the hearings, questionnaire, and report.

Sincerely,

ALBERT GORE, Jr., *Chairman,*
Subcommittee on Investigations and Oversight.

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98TH CONGRESS } HOUSE OF REPRESENTATIVES { REPORT
2d Session } { 98–621

REPORT STRUCTURAL FAILURES IN PUBLIC FACILITIES

MARCH 15, 1984.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. FUQUA, from the Committee on Science and Technology submitted the following

I. INTRODUCTION

During the past several years, there have been numerous cases in which new, widely used buildings, dams, and bridges have collapsed or failed to the point that immediate repairs were necessary to protect the public from injury. In some cases, as with the collapses of the Kemper Arena in Kansas City, Missouri, in June 1979, and the Hartford Civic Center in Hartford, Connecticut, in January 1978; the only damage that occurred was to the structure itself. No one was injured in those incidents since both buildings were empty at the time of collapse.

In many other cases, however, structural failures have resulted in personal tragedy as well. In June 1976, for example, the Teton Dam collapsed releasing tons of water which killed 11 people. And in July 1981, two elevated walkways collapsed in a Hyatt Regency Hotel in Kansas City, Missouri, killing 111 people and injuring 188 others.

On August 3 and 4, 1982, the Subcommittee on Investigations and Oversight held hearings to examine the problem of structural failures in this country. The Subcommittee convened its hearings out of concern over the damage and tragedies brought about by structural failures in the past and with the hope that similar failures could be prevented in the future. This report presents the Subcommittee's conclusions about how best to preclude such tragedies.

The need for a thorough review and analysis of the problem of structural failures has been emphasized further since the time of the Subcommittee's hearings. In the spring of 1983, a section of a major bridge in Connecticut simply gave way and fell into the river below. Fortunately, no one was killed in that accident, but the potential for a significant loss of life was tremendous; the bridge is part of Interstate 95 and a route for much traffic. Additionally, collapses of widely used buildings and structures in St. Louis, Missouri, and Newark, New Jersey, as well as in several other cities around the country, have occurred.

The testimony and information presented at the Subcommittee's hearings provided the basis for the findings and recommendations contained in this report. In preparation for its hearings, the Subcommittee staff conducted numerous interviews with principals of engineering design firms and construction firms. In conducting its investigation and hearings, the Subcommittee sought to determine (1) the underlying causes of structural failures and (2) what part, if any, shortcomings in technology or engineering training played in these failures. The purpose of the investigation was stated by Subcommittee Chairman Albert Gore, Jr. at the Subcommittee's hearing:

> We are not here to investigate the cause of any particular failure or to place blame on any part of the construction industry. Rather, our purpose [is] to obtain a better understanding of the actions that either take place, or fail to take place during the course of a building project which eventually results in failure. If we can do that, the industry may be able to determine measures which could help reduce the number of these occurrences.[1]

The Subcommittee believes that the findings and recommendations contained in this report represent a major step toward addressing the problem of structural failures.

A complete record of the Subcommittee's hearings entitled, "Structural Failures" can be obtained by contacting the Committee on Science and Technology's Publications Office, Room H2–108, HOB, Annex No. 2, Washington, D.C. 20515 (202/225–6275).

II. SUMMARY

If there is a predominant cause for structural failures it can be found in the interaction—and concomitantly, the lack of action—by the people who purchase, design, construct, and use buildings, dams, and bridges. The construction industry is a highly competitive industry, and often the speed with which a construction project can be completed has significant consequences for owners, developers, and construction firms. The desire for quick construction can result in short-cuts that in turn lead to omissions and errors in the construction process. Although written contracts, drawings, specifications, and memos technically guide the design/construction effort, the care and attention to detail by those involved in the construction activity itself, as well as their skill and sincerity, make the difference in the end.

Human errors—omissions or unverified field changes—can rapidly accumulate in the urgency of meeting building schedules. Although the Subcommittee found no example of a deliberate act for profit that contributed to a structural failure, the record suggests that efforts to reduce cost by eliminating vital services or restricting the time to accomplish various tasks has contributed to structural failures.

The central issue addressed by the Subcommittee during the course of its investigation and hearings was this: "Are there common problems associated with structural failures, the elimination of which

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[1] "Structural Failures: Hearings Before the Subcommittee on Investigations and Oversight of the House Committee on Science and Technology," 97th Congress, 2d Session 2 (1982) (statement of Representative Gore).

would decrease the number of failures?" In addressing this issue the Subcommittee sought to identify those factors which, in the opinion of the Subcommittee, contribute most significantly to the occurrence of a structural failure. These factors, along with those identified by the Subcommittee as less significant, are delineated below. This list is by no means exhaustive, but it does represent major elements of the structural failures problem that warrant serious attention by the building industry and the government.

The Committee found six significant factors that are critical in preventing structural failures. The Subcommittee also found five factors to be of heavy-to-moderate impact and eleven factors to be of lesser significance. The six critical factors are:

(1) communications and organization in the construction industry;
(2) inspection of construction by the structural engineer;
(3) general quality of design;
(4) structural connection design details and shop drawings;
(5) selection of architects and engineers; and
(6) timely dissemination of technical data.

The five moderately significant factors are:

(1) overall accountability for structural integrity;
(2) impact of "cost cutting" on design;
(3) impact of "cost cutting" on construction;
(4) potential for improving quality during construction; and
(5) selection of construction contractors.

The 11 least significant factors are:

(1) adequacy of building codes;
(2) impact of higher strength materials;
(3) adequacy of state and municipal design reviews;
(4) increased use of specialty contractors;
(5) support by testing laboratories;
(6) certification of buildings;
(7) role of lending institutions;
(8) adequacy of seismic codes;
(9) impact of construction manager type organization;
(10) impact of fast track scheduling; and
(11) need for legislative changes.

The Subcommittee has made formal findings and recommendations only for the six factors that it has concluded are of critical importance to structural failures. The Subcommittee believes that these factors warrant the greatest and most immediate attention by both government and the building industry.

In general, the Subcommittee has sought to identify ways to institute checks in the building process on the creation of errors that lead to structural failures. The Subcommittee has recommended a variety of actions that the building industry itself can take without the necessity of government attention. Such steps as the establishment of peer review procedures, the development of guidelines setting forth duties and responsibilities on construction projects, and the institution of quality control criteria all can be undertaken directy by professional societies and industry participants.

The Subcommittee has also, however, recommended that certain actions be taken by government agencies at both the local and federal

levels. For example, the Subcommittee has called for the inclusion in local building codes of a requirement that the structural engineer be on site during construction and a requirement that only licensed engineers be allowed to design structural connections. The Subcommittee has also recommended the creation within the federal government of a national investigative body to obtain information on structural failures, modeled on the widely respected and successful National Transportation Safety Board. Combined with the efforts of private industry, these actions could help prevent the causes of many structural failures.

III. ISSUE, FINDINGS, AND RECOMMENDATIONS

Issue

Are there common problems associated with structural failures, the elimination of which would decrease the number of failures?

Findings

The Subcommittee identified twenty-two factors that can contribute to structural failures. A complete list of these factors was delineated ing the preceding summary. The Subcommittee finds six of these factors to be of critical importance in causing (and conversely, preventing) structural failures. They are:

(a) Communications and organization in the construction industry;
(b) Inspection of construction by the structural engineer;
(c) General quality of design;
(d) Structural connection design details and shop drawings;
(e) Selection of architects and engineers; and
(f) Timely dissemination of technical data.

For these six factors the Committee makes the following findings:

(a) *Communications and organization in the construction industry.*—There is no set pattern for organizing design/construction projects. Virtually all projects are different, and the companies involved have different capabilities. The data received by the Subcommittee, however, through its hearings and investigation strongly indicate the existence of loosely structured organizations, unclear definitions of responsibility, and poor lines of communication between the participants in construction projects, all of which can contribute to the occurrence of a structural failure.

(b) *Inspection of construction by the structural engineer.*—For a variety of reasons, the structural engineer of record or his designee is often not present on the job site during the construction of principal structural components. The absence of the structural engineer has permitted flaws and changes on site to go unnoticed and uncorrected. One reason for the structural engineer's absence is the possibility that he or his firm could be subject to lawsuits which have no relationship to their project responsibilities.

(c) *General quality of design.*—The quality of design is being compromised by client desire to speed construction and reduce overall project costs. This can lead to the subsequent elimination of essential engineering services, such as peer reviews, that provide an impor-

tant check on the commission of errors in the design process and help ensure that high quality designs are produced.

(d) *Structural Connection design details and shop drawings.*—Structural connections, which are critical components of structural design, are often not designed by a structural engineer. Instead, they are frequently left to persons who do not have a sufficient understanding of the interaction of all stresses between structural members. Moreover, shop drawings are not sufficiently reviewed by the structural engineer. As a result, errors in design can be made and go unnoticed.

(e) *Selection of architects and engineers.*—The selection of architects and engineers is generally made on a "low bid" basis. Even when peer reviews, design scope, and on-site inspection are included in the bid request, there is a tendency to unrealistically reduce the price when price is known to be the primary basis for the contract award. Nearly exclusive use of this "low bid" procedure has frequently resulted in insufficient funds allocated to a project to adequately verify the accuracy of design and to thoroughly check plans before construction. In other words, selection of an architect or engineer solely on a price-competition basis provides the potential for reductions in quality due to initial underestimation of the costs and resources required to adequately perform the work.

(f) *Need for a national board to investigate structural failures.*—The records in many cases of litigation involving structural failures have been closed to public review as a result of settlement agreements between the parties. Consequently, little information has been made public about the technical causes of several recent major structural failures. Structural engineers and others have thus often been prevented from learning from the experiences and mistakes of others. This failure to disclose information provides the opportunity for others to commit the same mistakes in the future. A national investigative body is needed to obtain information about structural failures and provide individuals involved in the building industry with much-needed data on failures around the country.

Recommendations

With regard to the six factors outlined above that have been determined to be critical to the prevention of structural failures, the Subcommittee makes the following recommendations:

(a) *Communications and organization in the construction industry.*—With regard to project organization for design and construction work, the professional and building societies should jointly prepare guidelines prescribing the management, supervisory, technical, and quality assurance functions to be performed on a project, and should jointly prepare guidelines governing the conduct of design and construction work itself. The professional and building societies also should make recommendations on the qualifications of persons acting in management positions. Finally, before any construction project is commenced, the organizational responsibilities for each major project should be clearly and concisely defined in writing.

(b) *Inspection of construction by structural engineer.*—The structural engineer of record or his designee should be on the job site during the construction of principal structural components, especially on

large public projects and those involving new concepts, long-span structures, new components, or high-strength materials. Professional organizations, such as the Building Officials and Code Administrators International, the International Conference of Building Officials, and the Southern Building Code Conference International, should make every effort to ensure that provisions are written into building codes and adopted in public forum which make the on-site presence of the structural engineer mandatory during the construction of structural components on public facilities. Additionally, an evaluation of the problem of liability faced by structural engineers should be made.

(c) *General quality of design.*—It is recommended that the professional societies and government bodies make every possible effort to educate clients about the customs and practices of the construction industry and about the problems that can result when professional standards are compromised in an effort to reduce costs. To protect against errors or omissions in project design, a procedure for reviewing design details should be included to the greatest extent practicable in the design process.

(d) *Structural connection design details and shop drawings.*—Structural connections should always be designed by a licensed professional engineer and approved by the structural engineer of record. The structural engineer should then be accountable for the adequacy of the design. Again, it is recommended that professional organizations, such as the Building Officials and Code Administrators International, the International Conference of Building Officials, and the Southern Building Code Conference International, take action to ensure that building codes include this provision and that such provision is adopted in public forum.

(e) *Selection of architects and engineers.*—Federal procurement practices that lead to or promote the selection of architects and engineers on a "low-bid" basis should be changed to require prequalification of bidders, with greater consideration given to prior related experience and past performance on the part of those seeking the contract award. While price must be a factor, it should not be made available to those evaluating the bids until pre-selection of acceptable bidders has first been made on the basis of past experience and performance. The government should also ensure that all necessary architectural and engineering design and on-site services in public construction projects are furnished by licensed professionals who are qualified and experienced to assure the construction of safe structures.

(f) *Timely dissemination of technical data.*—The National Bureau of Standards (NBS) should be authorized on its own initiative to undertake investigations to determine the causes of major structural failures in public facilities and to collect and disseminate information on the causes of structural failures. The Bureau should initiate investigation of a major failure within 24 hours of its detection and report, at least on a preliminary basis, within 30 calendar days of the date of detection. For this purpose, the investigation should be initiated when, in the opinion of the Director of the Bureau, an investigation is warranted in order to promote public safety on future construction projects. In cases where the National Transportation Safety Board or the Corps of Engineers has authority to investigate,

the NBS should not investigate. When the staff of the National Bureau of Standards does not have a person with the proper technical skills or expertise in a particular discipline to investigate certain aspects of the investigation, the Bureau should then retain a person with such expertise. In no case should the NBS play a regulatory role in the construction industry. Information obtained from investigations of structural failures should be widely distributed to help prevent future structural failures.

IV. DISCUSSION OF CRITICAL FINDINGS AND RECOMMENDATIONS

A. Communications and Organization in the Construction Industry

Findings

There is no set pattern for organizing design/construction projects. Virtually all projects are different, and the companies involved have different capabilities. The data received by the Subcommittee, however, through its hearings and investigation strongly indicate the existence of loosely structured organizations, unclear definitions of responsibility, and poor lines of communication between the participants in construction projects, all of which can contribute to the occurrence of a structural failure.

Recommendations

With regard to project organization for design and construction work, the professional and building societies should jointly prepare guidelines prescribing the management, supervisory, technical, and quality assurance functions to be performed on a project, and should jointly prepare guidelines governing the conduct of design and construction work itself. The professional and building societies also should make recommendations on the qualifications of persons acting in management positions. Finally, before any construction project is commenced, the organizational responsibilities for each major project should be clearly and concisely defined in writing.

Discussion

The testimony presented at the Subcommittee's hearings indicated that sound organization of the construction project and good communications between parties are essential to the success of a project. Poor organization and lack of communication can lead to mistakes, omissions, or changes in plans or procedures that contribute to the occurrence of structural failures.

As revealed by the testimony presented at the hearings, one reason for the problems with organization and communications that have plagued construction projects is the fairly decentralized process employed by developers to select their construction team. According to Jim Crozier, Executive Vice-President of the Quadrangle Development Corporation, typically the developer selects an architect for the project, who in turn selects the structural, mechanical, and electrical engineers.[2] As a result, the developer rarely comes into contact with

[2] "Structural Failures: Hearings Before the Subcommittee on Investigations and Oversight of the House Committee on Science and Technology," 97th Congress, 2d Session 198–199 (1982) [hereinafter cited as Hearings] (statement of Mr. Crozier).

any party on the project other than the architect until very late in the construction process. Mr. Crozier believed that this limited contact prevented the developer from being fully apprised of any problems in either the design or construction of the project.[3] Mr. Crozier related that to remedy this situation some developers now directly select all the parties themselves.[4] This direct contact between the developer and both the architect and the engineers significantly enhances the flow of information between the parties. This process also facilitates informed decisionmaking by the developer, the party who is ultimately responsible for the project. By establishing direct contact, Mr. Crozier stated,

> [y]ou open up lines of communication that are not normally present when your owner works only with the architect. This way, it is possible for the engineers to call [the developer] on the phone and say, "[we] have got a real problem here with this design. Don't tell the architect I told you that, but we have a problem with the design.
>
> Opening up these channels, I think, is very, very important for the owner, developer to know what is going on. It puts the developer in a slightly higher position relative to structural safety, but if something happens to a building, ultimately it is the developer who is going to take the responsibility for it. So he might as well pick the man he wants.[5]

A second reason for organizational and communications problems on projects is that the duties and responsibilities of many parties are often ill-defined. The lack of clearly defined roles, when coupled with the desire to stay "on schedule" with a project, has frequently led to individuals making decisions outside their area of professional expertise and occasionally has resulted in actual conflicts between parties. Mr. Barry LePatner, an attorney who represents many architectural and engineering firms, explained the problem:

> [T]he coordination question . . . and the interplay between the design team, the owner, and the construction team is . . . critical. Because in many ways, each of these interests are intended to interface in a smooth way, and in reality, in many ways, they have an adversarial relationship [sic].
>
> The designer wants to design with every possible inclusion for safety, with every possible inclusion for aesthetics and would like the time to do all these things he has been well-versed from his days in architectural-engineering schools [sic.]
>
> The owner can't afford that time consideration even in the best of times. The contractor bids because he expects to complete a project within a certain amount of time, and every day after that costs him money out of his own pocket.
>
> So . . . once you understand that ongoing relationship, which is constantly in a state of flux during the construction process, is taking place, you can realize the very numerous

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[3] Id.
[4] Id. at 199.
[5] Id.

types of situations which can upset the balance of having a smooth flowing project . . .[6]

Mr. LePatner elaborated on the difficulties that can result from this situation:

> [T]here are great pressures that come to bear on an architect and engineer to insure that his design, for which he has gotten the owner's approval, gets carried through to completion.
>
> When you have problems during a project, whether they are delays, cost overruns, whether they are questions that come up in the field as to doing something differently than what is shown on the plans, the pressure from the owner is, well, let's do it, cheaper.
>
> The contractor can't get certain materials. He says let's substitute this other material. I can't get what I had agreed to provide. It is not available. I can do it cheaper. The architect and the engineer must make the decision. They are the final judges of the design criteria and it is imperative from their standpoint that the integrity of their design be maintained. Very often they lose in that decisionmaking process or they are not given the time to devote to making a careful study of a change that is made in the field.[7]

Mr. Randy Vosbeck, an architect and principal of VVKR, Inc., echoed Mr. LePatner's analysis and related how confused and overlapping roles can contribute to construction problems. As Mr. Vosbeck stated:

> There are now many more players in this whole process. Lines of responsibility are blurred much more than they used to be. . . .
>
> Usually, these days . . . the architect has much less of an opportunity to observe construction activities. Often, the owner would say, "Why should I pay the architect to perform this service, when I have got a construction manager on the job?" And, developers may say, "Why should I have an architect or engineer perform inspection services, when I have my own professionals there doing that kind of thing?" Or, the contractor may say, "Why should I have this welding X-rayed, when I know that I have competent welders on the job doing that work?"
>
> Everyone is under pressure to speed up the process, and this often creates a lack of attention to details and sound construction practices.
>
> In my view, with the design professional's role during the construction phase being minimized, as it is often times these days, the result can only be problems which will lead to potential failures.[8]

Mr. Shankar Nair, Chief Engineer with Alfred Benesch & Co., summed up the situation:

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[6] Id. at 184–185 (statement of Mr. LePatner).
[7] Id. at 185.
[8] Id., at 208–209 (statement of Mr. R. Randall Vosbeck).

> There is often no clear cut division of responsibility between architect, structural engineer, and detailer, and sometimes improper details get through the system." [9]

The Subcommittee has recommended that guidelines be developed by the appropriate professional societies that would prescribe with clarity the various functions to be performed in a construction project. These guidelines should be utilized by any project team involved in construction. The Subcommittee believes that if the duties and responsibilities on a project are clearly outlined prior to the initiation of construction, better organization of the project tasks can be achieved and better lines of communication can be developed.

The Subcommittee has not recommended that the guidelines actually assign the specific duties to certain parties. It is sufficient that the guidelines simply spell out the necessary functions to be performed. The matching of duties with personnel can be done well by the parties responsible for a given project. The important consideration is that clear roles and responsibilities—and thus decisionmaking authority—be assigned early in the project to prevent the type of confusion, miscommunication, and decisionmaking by improper and unqualified personnel that can lead to mistakes in the construction process.

While the Subcommittee has not called for the designation of specific parties and duties in the guidelines, the Subcommittee does believe that some measure should be taken to ensure that appropriate, qualified personnel in fact perform the tasks and make the decisions for which they are best qualified. Individuals should not perform work or exercise authority in areas in which they do not have sufficient expertise—even when there is great pressure to do so because of cost overruns or schedule delays. To guarantee that decisions are made by qualified personnel, the Subcommittee recommends that the appropriate professional and building societies suggest qualifications for persons acting in management positions. The wide-spread adoption of such criteria in the building industry would provide a valuable check on mistakes in the construction process.

Lastly, the Subcommittee recommends that the building and professional societies develop guidelines to govern the conduct of design and construction work itself. These guidelines would serve as overall "quality assurance" methods for construction projects. Such guidelines would provide a standard against which construction and design activities could be evaluated. This would help prevent undesirable shortcuts and substitutions in a construction project, as well as facilitate the general organization of the project effort.

B. Inspection of Construction by Structural Engineer

Findings

For a variety of reasons, the structural engineer of record or his designee is often not present on the job site during the construction of principal structural components. The absence of the structural engineer has permitted flaws and changes on site to go unnoticed and un-

[9] Interview with Mr. Shankar Nair (Apr. 15, 1982). See Appendix to this report.

corrected. One reason for the structural engineer's absence is the possibility that he or his firm could be subject to lawsuits which have no relationship to their project responsibilities.

Recommendations

The structural engineer of record or his designee should be on the job site during the construction of principal structural components, especially on large public projects and those involving new concepts, long-span structures, new components, or high-strength materials. Professional organizations, such as the Building Officials and Code Administrators International, the International Conference of Building Officials, and the Southern Building Code Conference International, should make every effort to ensure that provisions are written into building codes and adopted in public forum which make the on-site presence of the structural engineer mandatory during the construction of structural components on public facilities. Additionally, an evaluation of the problem of liability faced by structural engineers should be made.

Discussion

The structural engineer is one of the most important individuals in the construction process. His regular presence on the construction site can prevent errors that cause structural failures, and his absence can permit serious mistakes to go unnoticed and uncorrected.

The structural engineer is the person most likely to observe defects on-site, for it is he and his associates who make the calculations and review the project drawings as the construction design is developed. The structural engineer is thus intimately familiar with the details of the project when actual field work begins; no other person involved in the process shares this familiarity. As one witness stated, "The construction design engineer is the only man in the whole team who knows the intent of his design. When he visits the site, if he sees something wrong, he is the best man and in the best position to make that determination and call it to the attention of the proper authority." [10]

The absence of the structural engineer from the job site during construction of the structural components of a project has been consistently cited in cases in which structural failures have occurred. One case brought to the Subcommittee's attention involved the collapse of a huge wall (80 feet high and 100 feet long) that served as a moveable vane in a NASA wind tunnel at NASA's Ames Research Center in California. The wall, which was intended to withstand wind loadings in excess of 90 mph, failed because changes had been made in the design of the wall's adjustable control linkage. This change would have been noticeable by the structural engineer, and the failure could have been prevented. The engineers who designed the wall, however, never visited the job site to inspect the wall's construction. Many other examples exist.

The need for frequent on-site inspection by the structural engineer was stated emphatically by witnesses at the Subcommittee's hearings and by respondents to the Subcommittee's survey. Mr. Vincent Bush, representing the Council of American Building Officials, related:

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[10] Hearings, supra note 2, at 120 (statement of Mr. Vincent R. Bush).

> The structural engineer from the San Francisco Bay area who investigated the Kemper Arena, among other buildings, indicated to me sometime ago that in all the structural failures that he had investigated . . ., there was one common denominator, and that was the lack of monitoring of the construction by the design structural engineer.
>
> This ran through every one of them, and it is an important thing that must be changed.[11]

Mr. Bush pointed out that even when site visits are conducted by the structural engineer, it is rare that they occur with any degree of frequency or that the engineer's tour covers more than a few limited areas. As he related,

> . . . I just couldn't help but notice, looking at a guide for structural engineering services by the Construction Engineers Association of California, that they still have in their guide for services, that during the construction phase the structural engineer shall make site visits as necessary to observe and gain familiarity with the progress of the structural work.
>
> These construction phase services are really, I think, a euphemism for inspection because the word inspection or supervision, either one of those two words automatically carries a connotation that the structural engineer has taken over the job and this is not, of course, his responsibility but he can, and many of them do, make these inspections or construction site visits and when they see something wrong they call it to the attention of the proper authority [sic].
>
> The biggest problem is that it is not being done often enough.[12]

The inadequacy of even the site visits that do occur was stressed by Mr. Barry LePatner. Mr. LePatner asserted that the infrequency of visits by the engineer was the principal reason for this problem. He stated:

> Standard contracts which are widely used for owner-architect agreements in this country provide for only what is called periodic observation by the design professional team.
>
> Those contracts are not something configured merely at the whim of the American Institute of Architects, but they have been worked out jointly with the general contractors associations, and the Society of Engineers, and there is an ongoing review and analysis of these contract documents because of their wide use.
>
> What must be understood is that today the construction industry and owners as participant do not opt for having on-site residential inspection [sic]. In fact, that movement away from that over the years has caused this provision in the contract documents of the design team to use the word observation" instead of "inspection" because, since you are asked in

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[11] Hearings, supra note 2, at 119 (statement of Mr. Bush).
[12] Id.

> general to appear once or twice a week at the site, you cannot properly perform an inspection which involves a detailed investigation of what is going on.
>
> So, that word "observation" is more accurate and has become more widely used than "inspection".
>
> To the extent that remains the norm, you are going to have a wide gap between what is designed and what is ultimately constructed or little assurance to protect against a discontinuity between the approved set of design documents and what is ultimately constructed.[13]

Since it is desirable to have the structural engineer on site, the question naturally arises of why the engineer is not regularly present. Two considerations appear to contribute to the engineer's absence: (1) the threat of liability, and (2) the desire to minimize construction time and costs.

The threat of legal liability seems to be the greatest obstacle to the steady appearance of the structural engineer on the job site. The concern exists over liability in two respects. First, there is the obvious liability for design errors that go uncorrected. This liability is reasonable as long as the design is under the control of the structural engineer. If a structural engineer is on site or conducts an inspection and fails to notice or point out construction errors, potential liability could also exist.

Second, and actually of far greater concern to engineers, is the liability for failure to take corrective action when errors or accidents occur in areas contractually outside the structural engineer's responsibility. Several witnesses emphasized that this fear is principally responsible for keeping structural engineers away from the construction site. Mr. Harold Sandberg, President of Alfred Benesch & Co., made this point emphatically:

> . . . I would like to emphazize that this is a liability problem not for errors and omissions in design. This is liability for accidents that happen during construction. We have been told that the best thing to do, the strongest defense is, "Don't be there so you couldn't have had a chance of seeing the possibility of an accident".[14]

Mr. Shankar Nair echoed this statement:

> Engineers become nervous about getting involved in field construction. With today's potential for a lawsuit, if an engineer merely visits a job site, he is susceptible to being sued in connection with occurrences over which he has absolutely no control. . . . The legal liability factor makes engineers shy away from taking on any unnecessary obligations.[15]

Even when the structural engineer visits the construction site, the fear of liability often results in a less than thorough assessment of the project by him. The engineer frequently will focus his attention only upon those matters for which he is directly responsible and ignore other potential problem areas. As Mr. Sandberg stated:

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[13] Id. at 192 (statement of Mr. LePatner).
[14] Hearings, supra note 2, at 50 (statement of Mr. Sandberg).
[15] Interview with Mr. Nair (April 15, 1982). See Appendix to this report.

> But if you do go on a job, wear blinders, just go there to look at what you're supposed to look at. Don't let your eyes wander. If you do see something, [g]o to the superintendent of the contractor and tell him, "[M]aybe there is something wrong." Don't say there is, say, "Maybe there is something over there you should look at." Then beat it.[16]

In addition to the fear of liability for accidents and errors, concern over delays in the construction schedule—along with the potential for a resulting lawsuit—make structural engineers and others wary of visiting the construction site. Increasing costs, which create pressure to shorten the construction period, provide a tremendous incentive to minimize the role of both the structural engineer and the architect in the construction process.[17] Echoing this concern, Mr. Randy Vosbeck testified:

> It wasn't too many years ago I would go out on a construction site and if I would see something going on that I didn't like I would shut the job down as the architect and I wouldn't have any qualms about it and that was an accepted procedure.
>
> Nowadays, I think an inspector on the job doesn't dare do that because of the impact on the schedule, on other things that might happen. And so you are really walking on eggshells. You have that impression because of all of the potential problems that can occur.
>
> You run the risk of a claim from the contractor on slowing down his schedule. He is under contract to the owner to produce the job on time and those kind of things as well as the owner [sic].[18]

To combat the problems outlined above, the Subcommittee has made a number of recommendations intended to bring the structural engineer back into the construction process and maintain his regular presence on site.

First, quite directly, the Subcommittee recommends that the structural engineer of record or his designee should always be on the job site during the construction of principal structural components. As the preceding discussion illustrated, significant problems can be prevented by consistent inspections by the structural engineer. The Subcommittee believes that the appropriate building associations should ensure that the structural engineer's presence is required on site.

As the discussion above also related, however, a major obstacle—potential legal liability—currently prevents voluntary appearance by the structural engineer and could cause severe difficulties if the engineer's presence is required. The Subcommittee thus believes that an elevation of the liability issue should be made by the professional associations and any relevant Congressional committees, if appropriate. Consideration should be given to the desirability and feasibility of holding structural engineers—and architects, where appropriate—harmless from suits unrelated to their areas of responsibility on the job site. A thorough assessment of this matter would not only clarify the steps needed to be taken, but would reinforce the necessity of having the structural engineer on site.

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[16] Hearings, supra note 2, at 50–51 (statement of Mr. Sandberg).
[17] Id. at 192 (statement of Mr. LePatner).
[18] Id. at 211 (statement of Mr. Vosbeck).

C. General Quality of Design

Findings

The quality of design is being compromised by client desire to speed construction and reduce overall project costs. This can lead to the subsequent elimination of essential engineering services, such as peer reviews, that provide an important check on the commission of errors in the design process and help ensure that high quality designs are produced.

Recommendations

It is recommended that the professional societies and government bodies make every possible effort to educate clients about the customs and practices of the construction industry and about the problems that can result when professional standards are compromised in an effort to reduce costs. To protect against errors or omissions in project design, a procedure for reviewing design details should be included to the greatest extent practicable in the design process.

Discussion

It almost goes without saying that the overall quality of the project's design tremendously affects the likelihood of a structural failure. A good quality design avoids the possibility of errors that contribute to failures, while a poor quality design can cause major deficiencies to be built directly into the structure.

"Quality" is an elusive concept, but while it may not be possible to define quality, it is appropriate to state that the design is a "statement" that a structure built according to the design will adequately support the intended functions, loads, and ancillary equipment in a particular environment over a particular duration. The statement, communicated by drawings and specifications, should express the designer's intent clearly.

A principal reason for the problems with design quality is the general absence of peer review of designs. As costs have increased in the construction process and the desire for quicker construction time has grown, peer review of designs has sometimes been eliminated. The result has been designs that can sometimes contain serious errors that go undetected. Additionally, as the testimony indicated, the project designer frequently does not have experience in actual construction methods and practice. Designs thus can be created that seem flawless on paper but have significant problems in reality. Moreover, the criticism was made that, due to the nature of their academic training, many recent engineering graduates rely too much on computer analysis and computer aided design and have too little understanding of synthesis and overall design.

Mr. Lloyd Duscha, Chief of the Engineering Division of the U.S. Army Corps of Engineers, emphasized the importance of a proper review procedure to ensure good quality designs:

> An adequate design review process is . . . an essential element. In our program, all projects are subjected to varying independent levels of review according to the complexity of a project. These reviews serve to detect computational errors in design, to evaluate the assumptions and judgmental decisions, and to assure completeness in scope and detail.
>
> Engineering design is similar to other professions in that a second opinion may be appropriate, especially if the proj-

> ect is complex and innovative approaches are being tried. One technique is the use of expert consultants. Individuals or teams of consultants with recognized expertise are hired to review and comment on the design performed by others. This technique is especially useful when there are only a few available highly qualified experts in some engineering specialty.[19]

The absence of review is particularly egregious given the dichotomization of design tasks that exists in many projects due to cost pressures. These pressures frequently result in only minimally sufficient designs being accepted for a project. As Mr. John Archer, Chief Engineer of Burns and Roe, Architects and Engineers, pointed out:

> . . . [T]he engineer know[s] that his proposal will be judged primarily on price. He must, of course, get that price down. He cannot risk cutting corners by doing an inept design job but somehow he must reduce the time required to do the job. Instead of designing all of the project, why not write a specification that says the contractor will design and build part of the project? He can separate ou[t] pieces of the project that way, thus enabling himself to come out with a lower man-hour estimate for his participations in the project [sic].
>
> It is kind of cutting his own throat in that he is giving away work that he would be getting paid to do but if he doesn't give it away, he won't get the job in the first place because the owner is more and more selecting the engineer on the basis of how many man-hours does he say he can get this job done for [sic].
>
> The result of this delegation of design work is that it becomes the primary responsibility of the contractor that wins the bid to design and build some portion of the work.
>
> He may have some structural engineers on his staff. He may delegate the work further to an engineering organization that he will select, probably on a competitive price basis. Either his subcontract engineer or his captive engineers, if you will, will be under enormous pressure to provide a marginally adequate design because every bit of savings he can make in design are multiplied geometrically by the savings in construction costs.[20]

A good review process, in Mr. Archer's opinion, will correct this problem to a great extent and prevent the utilization of poor quality designs. In Mr. Archer's words: "The engineer should be required to review and approve the design that he has sloughed off to a contractor." [21]

A peer review procedure is thus important to ensuring good quality design, and the Subcommittee recommends that such a procedure be involved to the greatest extent practicable in the design process. The Subcommittee also believes, however, that the most significant factor contributing to poor quality designs is not the absence of peer review

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[19] Hearings, supra note 2, at 107 (statement of Mr. Duscha).
[20] Id. at 222 (statement of Mr. Archer).
[21] Id.

itself, but is rather the desire of responsible parties in the construction process to cut costs and reduce project time. As the discussion above related, it is the push to cut corners wherever possible that causes the design process to be shortened and lesser quality designs to be accepted in the first place. The Subcommittee consequently recommends that efforts be made by professional societies and government bodies to educate clients about the need to ensure that designs of the highest quality are produced. Educated and concerned participants in the design and construction process are the key to preventing structural failures due to errors in design.

D. Structural Connection Design Details and Shop Drawings

Findings

Structural connections, which are critical components of structural design, are often not designed by a structural engineer. Instead, they are frequently left to persons who do not have a sufficient understanding of the interaction of all stresses between structural members. Moreover, shop drawings are not sufficiently reviewed by the structural engineer. As a result, errors in design can be made and go unnoticed.

Recommendations

Structural connections should always be designed by a licensed professional engineer and approved by the structural engineer of record. The structural engineer should then be accountable for the adequacy of the design. Again, it is recommended that professional organizations, such as the Building Officials and Code Administrators International, the International Conference of Building Officials, and the Southern Building Code Conference International, take action to ensure that building codes include this provision and that such provision is adopted in public forum.

Discussion

It was stated to the Subcommittee that virtually every structural failure occurs because of some problem at a connecting point between structural members.[22] Because these points of connection can often be the weakest points in a structure, it is essential that they be designed properly to consider all the possible avenues of stress and force.

Unfortunately, however, the information presented to the Subcommittee at its hearings and through its investigation indicated that frequently insufficient care goes into the design of structural connections. The current practice in the building industry is to leave the design of the structural connections to the structural steel or precast concrete fabricator. As a result, individuals without adequate expertise often prepare the design details, which, needless to say, can produce substandard designs containing serious errors.

Mr. Alfred Perrone, a partner in the firm of Severud, Perrone, Szegezdy and Strum, explained the problem:

> The use of non-professional engineers and even personnel without engineering degrees in design work can result in failures. Particularly in steel construction, many so-called

[22] See Appendix to this report (statement of Dr. John Hanson).

> shop drawings, which contain much of the design detail, may be prepared by sub-professional people. If the steel fabricators do not use a qualified professional engineer who can spend a lot of time checking these drawings, there is opportunity for a failure.[23]

A secondary check on the preparation of inadequate connection design details would be a review of the fabricator's shop drawings by the structural engineer. Unfortunately, most engineering and architectural firms fail to review adequately the drawing to check for errors in design. In fact, frequently the design project has been completed for several months when the shop drawings are actually received for review. By that time, the firm is likely to be engaged in another project and has little or no time to devote to reviewing the drawings. Moreover, if the design was originally contracted on a law-bid basis, there may not be sufficient money allocated to the project to permit an adequate review.

To prevent the occurrence of errors in so crucial a phase of the building process, the Subcommittee has recommended that the structural connections be designed only by a licensed professional engineer. In this way, the initial problems created by the use of nonprofessional personnel in the design process can be avoided. Additionally, the Subcommittee has also recommended that all connection design details be approved by the structural engineer of record. As discussed in this report, the structural engineer is the person most familiar with both the totality of the project design and the interrelationship of the various design components. Review of the connection details by the structural engineer would provide a much-needed additional safeguard against built-in design errors.

E. Selection of Architects and Engineers

Findings

The selection of architects and engineers is generally made on a "low bid" basis. Even when peer reviews, design scope, and on-site inspection are included in the bid request, there is a tendency to unrealistically reduce the price when price is known to be the primary basis for the contract award. Nearly exclusive use of this "low bid" procedure has frequently resulted in insufficient funds allocated to a project to adequately verify the accuracy of design and to thoroughly check plans before construction. In other words, selection of an architect or engineer solely on a price-competition basis provides the potential for reductions in quality due to initial underestimation of the costs and resources required to adequately perform the work.

Recommendation

Federal procurement practices that lead to or promote the selection of architects and engineers on a "low-bid" basis should be changed to require prequalification of bidders, with greater consideration given to prior related experience and past performance of the parties seeking the contract award. While price must be a factor, it should not be made available to those evaluating the bids until pre-selection of ac-

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[23] Id. (statement of Mr. Perrone).

ceptable bidders has first been made on the basis of past experience and performance. The government should also ensure that all necessary architectural and engineering design and on-site services in public construction projects are furnished by licensed professionals who are qualified and experienced to assure the construction of safe structures.

Discussion

As the individuals who conceptualize and design the building projects, architects and engineers obviously play an important role in ensuring that a project is successful and free of structural defects. It is therefore essential that the architect and engineers for a project be selected principally on the basis of their skill, experience, and professional qualifications.

Significant concern was expressed to the Subcommittee during the course of its inquiry that cost considerations too greatly affect the selection of architects and engineers to the detriment of quality work. Considerable blame for this situation was placed on the competitive bidding process now utilized for building projects. The widespread belief exists among participants in the building process that competitive bidding leads to "low-balling"—that is, to the submission of unrealistically low cost proposals. This in turn results in efforts by the victorious contractor to cut costs and shorten the project period. As discussed previously, such efforts are a major reason for errors in design and construction that result in structural failures.

One reason for the persistence of the present bidding system obviously is the desire on the part of owners and developers to save money. Equally significant, however, in the opinion of some witnesses, is that in many cases the individuals who actually select the architects and engineers for projects have little understanding of the intricacies of the building process and the need to ensure quality work throughout it. As Mr. Barry LePatner related:

> The public's image of architects and engineers remains two dimensional. Without a true understanding of the training, skills, and qualities needed to orchestrate a successful project, even those who retain an architect often fail to appreciate the diverse responsibilities and pressures that come to bear in bringing a project to fruition.[24]

The Subcommittee is concerned that the current competitive bidding system does in fact contribute to the occurrence of structural failures. The Subcommittee also appreciates, however, the desire to minimize costs and conserve resources in the building industry. The objective is to balance these competing considerations without endangering public safety. Accordingly, the Subcommittee has recommended, a least with regard to federal building projects, that the federal government review its current procurement practices and revise them to give greater consideration to the qualifications of architects and engineers. Such a revision would constitute an important step toward ensuring that structural failures are prevented at the earliest point in the building process—i.e., in the selection of architects and engineers.

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[24] Hearings, supra note 2, at 172 (statement of Mr. LePatner).

F. Timely Dissemination of Technical Data

Findings

The records in many cases of litigation involving structural failures have been closed to public review as a result of settlement agreements between the parties. Consequently, little information has been made public about the technical causes of several recent major structural failures. Structural engineers and others have thus often been prevented from learning from the experiences and mistakes of others. This failure to disclose information provides the opportunity for others to commit the same mistakes in the future. A national investigative body is needed to obtain information about structural failures and provide individuals involved in the building industry with much-needed data on failures around the country.

Recommendations

The National Bureau of Standards (NBS) should be authorized on its own initiative to undertake investigations to determine the causes of major structural failures in public structures and to collect and disseminate information on the causes of structural failures. The Bureau should initiate investigation of a major failure within 24 hours of its detection and report, at least on a preliminary basis, within 30 calendar days of the date of detection. For this purpose, the investigation should be initiated when, in the opinion of the Director of the Bureau, an investigation is warranted in order to promote public safety on future construction projects. In cases where the National Transportation Safety Board or the Corps of Engineers has authority to investigate, the NBS should not investigate. When the staff of the National Bureau of Standards does not have a person with the proper technical skills or expertise in a particular discipline to investigate certain aspects of the investigation, the Bureau should then retain a person with such expertise. In no case should the NBS play a regulatory role in the construction industry. Information obtained from investigations of structural failures should be widely distributed to help prevent future structural failures.

Discussion

Throughout the Subcommittee's inquiry, the point was made that many structural failures result from errors that could have been avoided had better information been available to the parties involved in the building process. Often, errors or omissions in design or construction parallel flaws made in other projects that failed. A good flow of information about these earlier errors might have prevented their recurrence in other projects.

Unfortunately, information about previous failures frequently is unavailable to the public because of lawsuit settlements. Litigation typically has resulted from major structural failures, and one characteristic of settlement agreements in these cases has not uncommonly been a provision that the records be sealed. These agreements to keep confidential the basic facts behind many structural failures have thus deprived others involved in the building industry of the opportunity to learn from past mistakes and to avoid them in the future. As Mr.

Barry LePatner stated, "Good judgment is usually the result of experience. And experience is frequently the result of bad judgment. But to learn from the experiences of others requires those who have had the experience to share the knowledge with those who follow." [25]

The case of the John Hancock Building in Boston illustrates the concerns that exist about the sealing of records. That building had been plagued by windows that would become detached from their casings and fall many stories to the ground, damaging the building and endangering passers-by. No information is publicly available on the cause of this phenomenon, however, because of a settlement agreement in the case keeping all records secret. Mr. LePatner testified:

> The recently settled litigation involving Boston's John Hancock Building highlights this point. During seven years of litigation, millions of dollars were spent by the various parties in securing legal and expert analysis of the window failures and related structural problems. The notoriety of this case led to the expectation that such exhaustive investigation by the Nation's foremost engineering experts would lead to improved design at best, and, at the least, methods by which future failures of this kind could be avoided. To the amazement and chagrin of many when this case was settled, the parties secured a court order sealing all records of this action. One can only hope that when the litigation involving the Kansas City Hyatt collapse is concluded, the various expert reports, however conflicting, will be made public so that the lessons of that failure can be utilized to avoid a tragic recurrence.[26]

Nearly all the witnesses at the hearing were critical of arrangements, such as that in the John Hancock case, that preclude the free flow of information about the cause of structural failures, whether in major structures or smaller ones. As Mr. Bob Loomis asserted, "When there is a structural failure, the real cause is not distributed throughout the profession, so there is little opportunity to learn from the mistakes of the past. As soon as there is a failure, the lawyers get involved and begin fighting and no one finds out what the mistakes were." [27] Dr. Richard Wright of the National Bureau of Standards echoed this concern: "It keeps away from the whole engineering, architectural, and building community information that would be very helpful in avoiding the repetition of . . . failures." [28]

Consistent with their concern over the restricted flow of information, many witnesses voiced their support for some form of national clearinghouse for information on structural failures. The design preferred was an organization that would investigate failures, collect data on their causes, and disseminate this information widely throughout the building industry. The entity would function similarly to the highly respected National Transportation Safety Board. When appro-

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[25] Id. at 174 (statement of Mr. LePatner).
[26] Id.
[27] See Appendix to this report (statement of Mr. Loomis).
[28] Hearings, supra note 2, at 94 (statement of Dr. Wright).

priate, the organization would also make recommendations for future action with regard to the particular structural failure investigated.

Mr. Jerome Cooper, representing the American Institute of Architects, best stated the case for a national information repository:

> Fundamental to this whole thing is a given and that is most owners do not want to build buildings that are going to fall down. Most architects do not want to be involved with them and most contractors do not want to be involved with them.
>
> If there is a design error or a construction error, most owners would welcome knowing that, assuming that it did not prejudice their legal claims against any of the parties involved.
>
> I think most professionals would welcome knowing that and would take steps to correct that. I think that simple information coming from some central agency, some clearinghouse of information would place most architects, even just ordinary people, on notice that there were problems and we would take steps ourselves to correct our own practices.[29]

In response to the concerns expressed by the witnesses, the Subcommittee has recommended that the National Bureau of Standards (NBS) be invested with authority to investigate structural failures and disseminate information about them. This concept received strong support from many of the witnesses at the Subcommittee's hearings.[30] The NBS currently investigates structural failures and thus has significant expertise in discerning their causes. Presently, however, the NBS can investigate a structural failure only at the invitation of a state or local government or an appropriate federal agency.[31] The NBS should be granted the authority to conduct investigations on its own initiative in order to ensure that it will be able to gather a broad range of information and subsequently disseminate it throughout the building industry.

To ensure that NBS inquiries are timely, the Subcommittee has also recommended that any NBS investigation be initiated within 24 hours of the occurrence of the failure and that the NBS issue a report—whether preliminary or final—within 30 days of the failure. Moreover, to avoid duplication of effort, the Subcommittee believes that the NBS should not investigate incidents in which the National Transportation Safety Board or the Army Corps of Engineers has authority to investigate.

Finally, the Subcommittee wishes to emphasize that the NBS's role in seeking the cause of structural failures would be purely one of investigation and information collection and dissemination. The Subcommittee's intent is that the NBS would not have a regulatory role in the construction industry. Instead, any conclusions or recommendations put forth by the NBS as a result of an investigation would be advisory only and would stand or fall on the force of their logic and reasonableness.

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[29] Id. at 99 (statement of Mr. Cooper).
[30] See, e.g., id. at 93–96.
[31] Id. at 94 (statement of Dr. Richard N. Wright).

V. DISCUSSION OF OTHER CONTRIBUTING FACTORS

A. Factors of Heavy to Moderate Impact on Structural Failures

In addition to the six critical factors discussed in the preceding section of this report, the Subcommittee identified five factors that play a significant, though less important, role in the occurrence of structural failures. Those five factors are:

(1) Overall accountability for structural integrity;
(2) Impact of "cost cutting" on design;
(3) Impact of "cost cutting" on construction;
(4) Potential for improving quality during construction; and
(5) Selection of the construction contractor.

Although the Subcommittee concluded that these factors did not warrant formal findings and recommendations, some discussion of their relevance is useful to provide a fuller picture of the problems that result in structural failures. Accordingly, each factor is considered briefly below.

(1) *Overall accountability for structural integrity.*—The question addressed by the Subcommittee was who, if anyone, should be accountable overall for the integrity of a structure. In a significant number of failures the absence of a single, central authority resulted in "finger pointing" during subsequent investigations and court proceedings. This effort to shift blame after a failure does little to help determine the true cause of a failure and thereby avoid similar problems on future projects.

It is clear that either the architect or the structural engineer should be accountable. The Subcommittee believes that it may be necessary to resolve this issue in order to avoid failures in the future. It may be useful to designate one party to assume overall structural responsibility for a project, with delegation of authority and a clear line of responsibility to those who might participate in elements of design or on-site inspection.

(2) & (3) *Impact of "cost cutting" on design and construction.*—Testimony presented at the hearings emphasized that efforts to reduce costs frequently have negative effects on the quality of a project's design and construction. These impacts have been discussed to some extent in a different context in the preceding section of this report. The point should be well taken, however, that the relatively small amount of money saved from the design and construction budgets by these efforts is often greatly overshadowed by the costs that result when a failure occurs and lawsuits ensue.

(4) *Potential for improving quality during construction.*—As discussed previously in this report, there is much room for improvement in the quality of many construction projects. The desirability of review procedures for ensuring the quality of design was considered particularly important by many witnesses. Similarly, a formal system of checks and verification can help ensure quality during the construction phase of the project. Qualified field personnel and inspectors, who are themselves not involved in the actual construction work, are essential.

(5) *Selection of the construction contractor.*—As with architects and engineers, construction contractors for projects are chosen on the basis of low-bid submissions. This process, however, has sometimes resulted in less than competent contractors acquiring projects, with resulting disastrous consequences. Even more frequently, especially with regard to government contracts, contractors have deliberately submitted unrealistically low bids and then enhanced their profits by later submitting claims that argue that conflicts exist in the drawings and specifications. The process of awarding contracts in this fashion should be reviewed and greater consideration given to the qualifications and professional reputation of the contractor seeking the award.

B. Factors of Lesser Importance

The Subcommittee also identified eleven factors that, while not significant in forming the underlying causes of structural failures, nonetheless require some consideration. The comments below are brief distillations of the testimony received by the Subcommittee about each item. While each of these factors can contribute in some way to the occurrence of a failure, none by itself was considered instrumental in causing failures. The 11 factors are:

(1) *Adequacy of building codes.*—Building codes were generally focused to be adequate although not up to date with improvements in technology. Such codes should be considered only as minimum design standards.

(2) *Impact of higher strength materials.*—Greater knowledge and awareness of the benefits of high-strength materials is needed on the part of both engineers and tradesmen in the field. Use of such materials could help decrease the incidence of structural failures due to weaknesses in the building materials themselves.

(3) *Adequacy of state and municipal design reviews.*—State and municipal design reviews cannot be taken as a guarantee that a structure will not fall. State and municipal officials have no responsibility for the adequacy of design or construction. While an experienced government inspector may catch a mistake and thereby contribute to structural integrity, there is no law that holds him accountable for not finding mistakes.

(4) *Increased use of specialty contractors.*—The use of specialty contractors seems neither to detract from nor enhance structural safety. The qualifications and competence of the general contractor himself is of greater importance.

(5) *Support by testing laboratories.*—Support by testing laboratories was found to be excellent. It has to be understood however, that laboratories will only do what they are contracted to do. Laboratory personnel should not be expected to act as policemen for a project and investigate matters on their own.

(6) *Certification of buildings.*—The certification of buildings was not considered to be of prime importance in preventing structural failures. It was noted, however, that certification could be a method to help prevent the misuse of structures by owners.

(7) *Role of lending institutions.*—Lending institutions could have some influence in preventing structural failures by evaluating the experience record of developers and builders before making construction

loans, Most financial institutions are not well staffed for such purposes, however.

(8) *Adequacy of seismic codes.*—Seismic codes were found to be less than adequate. Seismic studies using centrifuge facilities built by the National Aeronautics and Space Administration (NASA) have been made, but there is still a need for considerable design conservatism. Engineers should consult with universities and other engineers when their work is geographically located in an area where earthquakes have occurred.

(9) *Impact of construction manager type organization.*—The "construction manager" type organization was not identified as having unusual potential for structural failures. As previously noted, however, inadequate project organization and communication can be a prime cause of structural failures. If the "construction manager" type organization is used, the essential project functions still have to be staffed with experienced personnel. If the "construction manager" is nothing more than a broker who contracts for all services and has little or no project staff with the necessary experience, the project could experience failure due to errors or omissions in the construction process.

(10) *Impact of "fast track" scheduling.*—Fast track scheduling by itself does not cause structures to fail. On the other hand, fast track scheduling can lead to time constraints which do not allow sufficient time for adequate design verification. Should this be the case, the probability of a structural failure could be increased.

(11) *Need for legislative changes.*—Because the Subcommittee did not set out to regulate structural integrity in the building industry, no regulatory legislation has been contemplated. The Subcommittee has noted previously in this report, as with the NBS investigatory unit, that certain nonregulatory legislative changes may be desirable. The Subcommittee's other recommendations can be achieved through nonlegislative actions by government agencies and through private initiatives by professional societies.

VI. Names and Addresses of Contributors

The Committee on Science and Technology, having completed its work on the integrity of structures, would like to express its sincere appreciation for the overwhelming response provided by the members of the construction industry; those individuals who came to Washington to appear before the committee as witnesses to discuss ways to enhance the integrity of public structures; those who contributed time and expertise in discussions on structural issues with the committee staff; those who responded to lengthy questionnaires by providing many valuable comments; and those who submitted illuminating material for the record. The committee also expresses its many thanks to those professional societies who assisted in this effort.

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Commonwealth of Kentucky, Department of Housing, Buildings, and Construction, Frankfort, KY 40601.

Commonwealth of Pennsylvania, Department of Community Affairs, Harrisburgh, PA 17120.

Connecticut Mutual Life Insurance Company, 140 Garden Street, Hartford, CT 06115.

Connolly Development, Inc. 1990 Third Street, Sacramento, California 95814.

Mr. Jerome M. Cooper, Cooper, Carry & Associates, 1819 Peachtree Rd., Atlanta, GA 30309.

Cowen Associates, 29 Vesta Road, Natick, Massachusetts 01760.

Mr. James Crozier, Quadrangle Development Corporation, 2030 M Street, Washington, D.C. 20036.

Dallas/Fort Worth Airport, East Airfield Drive, Dallas/Fort Worth, Texas 75261.

Department of the Navy, Naval Facilities Engineering Command, Norfolk, Virginia 23511.

Department of the Navy, Naval Facilities Engineering Command, San Bruno, CA 94066.

Mr. Lloyd Duscha, U.S. Army Corps of Engineers, 20 Mass. Ave., NW, Washington, D.C. 20314.

Enwright Associates, Inc., Box 5287, Station B, Greenville, South Carolina 29606.

Mr. David T. Evans, P.E. U.S. Department of Commerce, Washington, D.C. 20230.

First Union Corporation, First Union Plaza, Charlotte, North Carolina 28288.

Florida Department of Transportation, 605 Suwannee Street, Tallahassee, Florida 32301.

Florida Hospital, 601 Rollins Road, Orlando, Florida 32802.

General Services Administration, Washington, D.C. 20405.

Geologic Associates, Inc., P.O. Box 668, Franklin, Tennessee 37064.

Geupel DeMars, Inc., 1919 North Meridian St., Indianapolis, Indiana 46206.

Harris Bankcorp, Inc., 111 W. Monroe Street, Chicago, Illinois 60603.

Harza Engineering Company, 150 South Wacker Drive, Chicago, Illinois 60606.

Mr. Key Hickman, Volpe Construction Company, 5200 Auth Road, Suitland, MD 20746.

Hospital Building & Equipment Co., 717 Office Parkway, St. Louis, Missouri 6341.

Idaho Department of Labor & Industrial Services, 523 E. Twelfth St., Des Moines, Iowa.

Illiana Engineering, Inc., 1200 Sheffield Avenue, 7–B, Dyer, Indiana 46311.

Illinois Department of Public Health, 535 West Jefferson Street, Springfield, Ill. 62761.

International Conference of Building Officials, 5360 S. Workman Mill Rd., Whittier, CA 90601.

J. E. Dunn Construction Company, 929 Holmes, Kansas City, Missouri 64106.

Jack D. Gillum Associates, 100 North Broadway, St. Louis, Missouri 63102.

Jones & Henry Engineers Limited, 2000 W. Central Ave., Toledo, Ohio 43606.

Mr. Peter Keleti, 4310 Gillham Road, Kansas City, Missouri 64110.

Charles J. Kupper, Jr., 1034 Millstone Road, Somerville, New Jersey 08876.

Mr. Barry LaPatner, Park Avenue Plaza, 55 E. 52nd Street, New York, New York 10055.

Lev Zetlin & Associates, 95 Madison Avenue, New York, New York 10016.

Libby, Owens, Ford, 811 Madison Ave., P.O. Box 799, Toledo, Ohio 43695.

Liberty National Life Insurance Company, P.O. Box 2612, Birmingham, Alabama 35202.

Loomis and Loomis, 30 Maple Avenue, Windsor, Connecticut 06095.

Massachusetts Mutual Life Insurance Company, 1295 State Street, Springfield, MA 01111.

McCulloch Realty, Inc., Kirkeby Center, Suite 1130, 10880 Wilshire Blvd., Los Angeles, CA 90024.

Michigan Dept. of Labor, Bureau of Building Codes, 7150 Harris Dr., Lansing, MI 48909.

Microelectronics Center of North Carolina, P.O. Box 12889, Research Trangle Park, NC 27709.

Mississippi State Building Commission, 1501 Sillers Building, Jackson, Mississippi 39202.

Modeski and Masters, P.O. Box 2345, Harrisburg, Pennsylvania 17105.

Mr. Joseph F. Murphy, 5727 Richmond Drive, Madison, Wisconsin 53719.

National Life and Accident Insurance Company, National Life Center, Nashville, TN 37250.

National Research Council, 2101 Constitution Ave., Washington, D.C. 20418.

New Jersey Department of Transportation, W. State & Willow Sts., Trenton, NJ 08625.

New York City Transit Authority, 370 Jay Street, Brooklyn, NY 11201.

New York Life Insurance Company, 51 Madison Avenue, New York, New York 10010.

New York State University Construction Fund, P.O. Box 1946, Albany, New York 12201.

Northbrook Excess & Surplus Insurance Company.

Northwestern National Life Insurance Company, 20 Washington Ave., S., Minneapolis, MN 5544.

Ohio Department of Transportation, 25 S. Front St., Columbus, Ohio 43216.

Pacific Mutual Life Insurance Company, 700 Newport Center Dr., Newport Beach, CA 92660.

Phoenix Mutual Life Insurance Company, One American Row, Hartford, CT 06115.

Pittsburgh-Des Moines Corporation, 3400 Grand Ave., Neville Island, Pittsburgh, PA 15225.

Pratt Hotel Corporation, 4099 McEwen, Dallas, Texas 75240.

Professional Engineers in Private Practice, 2029 K Street, NW, Washington, D.C. 20006.

Provident Mutual Life Insurance Company, P.O. Box 7378, Philadelphia, PA 19101.

Purdue University, West Lafayette, Indiana 47907.

Ruttenhous-Zeman & Associates, Inc., 13837 N.E. 8th Street, Bellevue, Wash. 98005.

Rummel-Klepper & Kahl, 1035 N. Calvert Street, Baltimore, Maryland 21202.

Mr. Harold Sandberg, The American Consulting Engineers Council, 1015 15th Street, NW., Washington, D.C. 20006.

Seattle-First National Bank, 821 Second Avenue, Seattle, Washington 98104.

Security Pacific National Bank, 333 S. Hope St., Los Angeles, California 90071.

Severud Perrone, Szegezdy, Sturm, 485 Fifth Avenue, New York, New York 10017.

Sherwin P. Asrow & Associates, 224 S. Michigan Ave., Suite 511, Chicago, Illinois 60604.

Mr. Warren C. Stadden, 315 East Fifth Avenue, Roselle, New Jersey 07203.

State of Alabama Highway Department, Union Street, Montgomery, Alabama 36130.

State of California, Department of Transportation, Sacramento, California 95807.

State of Colorado, Division of Housing, 1313 Sherman Street, Denver, Colorado 80203.

State of Minnesota, Div. of Building Construction, 200 State Adm. Bldg., St. Paul, MW 55155.

State of Montana, Building Codes Division, Capitol Station, Helena, Montana 59620.

State of Nebraska, Department of Water Resources, P.O. Box 94676, Lincoln, Nebraska 68509.

State of Nevada Public Works Board, Capitol Complex, Carson City, Nevada 89710.

State of New Jersey, Department of Community Affairs, 363 W. State Street, Trenton, N.J. 08625.

State of North Dakota, Department of State, Bismarck, North Dakota 58505.

State of Ohio, Board of Building Standards, P.O. Box 825, Columbus, Ohio 43216.

State of Oklahoma, State Board of Public Affairs, 306 State Capitol Bldg, Oklahoma City, Okla.

State of Oregon, Department of General Services, 1225 Ferry St., DE, Salem, Oregon 97310.

State of South Carolina, Division of General Services, 300 Gervais St., Columbia, SC 29201.

State of Tennessee, Div. of Facilities Management, Nashville, Tennessee 37219.

State of Vermont, Agency of Transportation, 133 State Street, Montpelier, Vermont 05602.

State of Vermont, Dept. of Labor and Industry, 120 State St., Montpelier, Vermont 05602.

State of Washington, Department of Transportation, Olympia, Washington 98504.

State of Wisconsin, Dept. of Industry, Labor & Human Relations, P.O. Box 7967, Madison, WI 53707.

T.Y. Lin International, 315 Bay Street, San Francisco, CA 94133.

Texas Commerce Bancshares, Inc., P.O. Box 2558, Houston, Texas 77001.

Texas Department of Health, 1100 West 49th Street, Austin, Texas 78756.

The Bank of New York, Co., Inc., 48 Wall Street, New York, New York 10015.

The Equitable Life Assurance Society of the United States, 1285 Ave., of the Americas, New York, New York 10019.

The Travelers, One Tower Square, Hartford, CT 06115.

Union Mutual Life Insurance Company, P.O. Box 9548, Portland, Maine 04122.

U.S. Army Corps of Engineers.

Veterans Administration, Medical Center, Poplar Bluff, MO 63901.

Mr. C. Roy Vince, Shand, Morahan & Company, 1 American Plaza, Evanston, Illinois 60201.

Mr. R. Randall Vosbeck, 720 N. Asaph Street, Alexandria, Virginia 22314.

Walker Engineering, P.O. Box 2378, Pocatello, Idaho 83201.

Washington Metropolitan Area Transit Authority, 600 Fifth St., Wash., D.C. 20001.

West Virginia Department of Highways, 1900 Washington St., East, Charleston, W.Va. 25305.

Western & Southern Life Insurance Company, 400 Broadway, Cincinnati, Ohio 45202.

William H. White, 29 Annett Avenue, Edgewater, New Jersey 07020.

Wiss, Janney, Elstner & Assoc., 330 Pfingsten Road, Northbrook, Illinois 60062.

Dr. Richard Wright, Dir., Center for Building Technology, National Bureau of Standards, Room B368, Washington, D.C. 20234.

Wright-Pierce, 99 Main Street, Topsham, Maine 04086.

VII. APPENDIX

Appendix A.—Interviews With Selected Principals of Engineering and Construction Firms

Discussion with Mr. T. Y. Lin, T. Y. Lin International—January 24, 1982

The meeting was held in Professor Lin's office to discuss the general subject of structural defects in new public facilities. Professor Lin was not sure that there was an abnormal number of such failures considering the magnitude of new construction projects in the country. He was concerned about the durability of new materials available to the design engineer, but he did not believe that advancements in technology had anything to do with the recent structural failures.

The meeting was especially invigorating since Professor Lin is so enthusiastic about his work. For a man with his record of accomplishments, his genuine excitement when discussing a project was refreshing. As he spoke of general problems, he thought that the younger engineers did not pay sufficient attention to the overall design, but instead, relied too heavily on mathematics and computer results. In his wisdom, he sincerely worries about the next generation of engineers. He asks, "Will they see the big picture or merely rely on calculations?" The new generation of engineers may rely too heavily on the answers from computers. Professor Lin believes young engineers need more experience and mentioned that perhaps six years of education with more time spent on practical matters would help. He states that basic engineering, laboratory and computer results must all agree. If they don't, something is probably wrong. The basics can't be neglected.

Professor Lin believes in scale model tests, but understandably worries about "scaling factors." He believes new earthquake technology is resulting in new buildings which are better able to withstand earthquake shocks even though many of them are taller structures.

Regarding buildings codes, he emphasized that they only establish "minimums". Also, the letters of the codes may not correctly convey the intent, and that may create a barrier for improvements in safety and economy. They must be considered in conjunction with what is to be accomplished. We felt that in the past, the engineering schools placed too much emphasis on mathematics and the computer.

Before leaving, he mentioned that more laboratory work would help. "Maybe more seismic tables, like the one at Berkeley. Also, more wind tunnel availability."

Discussion with Robert S. Loomis, Loomis and Loomis—February 9, 1982

Bob Loomis operates a small professional engineering firm in Windsor, Connecticut.

In his striving for perfection, he states flatly, "The basic system is fundamentally wrong." (Editor's note: meaning the way the design-construction industry actually functions.) He believes most structural engineers are competent enough, but they are at the "bottom of the totem pole." They are too remote from the owner/developer for one thing, and you need a decent fee to do a decent job, says Bob. He feels engineers are pressured into reducing their fees. There are always limitations on spending and owner/developers "shop" for architects and engineers.

Bob felt that the owner/developers should have total liability. This would prompt insurance companies to be more aware of the project in which case they might well turn to architects/engineers to check the work. Or they could develop their own staffs to do the checking. In order for this to work the insurance companies would need the freedom to set rates according to the risk involved without government interference in the process. In this way the premium costs would encourage upgrading of old structures and better quality in new ones.

Bob believes any constructive changes would have to be made on a State by State basis. Government building departments are in general not sufficiently competent to assure the quality of a structure. Bob does not believe that the professional licensing system is very effective. He states, "Professional licensing has no good effect that I am aware of. By requiring an engineer's seal on a drawing the State encourages employees in industrial plants to obtain the seal without doing the work. And it tends to reduce all engineers to the same level in the public's eye."

Another area that is not effective is communications. When there is a structural failure, the real cause is not distributed throughout the profession, so there is little opportunity to learn from the mistakes of the past. As soon as there is a failure, the lawyers get involved and begin fighting and no one finds out what the mistakes were.

Mr. Loomis related that he set up the By Laws for the old Consulting Engineers Association of Connecticut and included a Professional Practices Commission. One main purpose of this Commission was to be a clearing house for information on engineering problems. He had hoped that it could investigate mishaps of various degrees of seriousness and disseminate information so all the engineers in the state could benefit. The engineering profession did not want the Commission and it was disbanded. Scientific investigations which would benefit the engineering community are hampered by the legal profession and the financial impact that such an investigation might have on a company.

He continued, "As a result of our analysis of a large structural failure we evolved a theory which met all of the physical conditions which we could determine at the site. Some testing of individual members similar to those in the collapsed system could have provided the ultimate evidence that we were correct. Engineers from a major company involved were interested in doing the testing but I understand that the company attorneys would not permit it. There is no concerted attempt to find the truth to prevent future calamaties. Everyone is in court to protect himself. This is the kind of thing I had hoped the Professional Practices Commission could have worked on.

We discussed the approval of shop drawings. (Editor's Note: shop drawings are prepared by steel or concrete fabricators and normally submitted by the construction contractor to the owner for approval). Mr. Loomis mentioned that courts have held that if a representative of the owner approves the shop drawing, then he could be held responsible for the design. He said that normally the architect or engineer as the designer, is representing the owner at this point. The insurance company has them "review" rather than "approve" shop drawings. There are many details on the shop drawing that are more for the fabrication of parts than for basic design requirements. An "approval" could mean that the person who did the approving accepted the responsibility for these fabrication items when the intent was to review for the design items. The designer's efforts should be concentrated in checking for what the final product will do and not for how it will assemble. (Editor's Note: seldom would an owner have the capability to verify the adequacy of structural detail unless he had retained an engineering firm for this purpose).

We talked about research and development as it applies to structure. In general, Mr. Loomis felt that universities frequently do research which is not well distributed to engineering firms. He mentioned that LeHigh University Testing Laboratory is excellent. He did feel that some of the university R&D was better 20 years ago, particularly in the area of rigid frames and composites.

Mr. Loomis mentioned that certifying public facilities might enable the public to recognize when a building was safe and that the certification process might give owners cause to provide for quality, particularly if a private insurance company was involved as the certifier. Insurance companies should concentrate on preventing failures, not assessing losses.

Mr. Loomis did not believe in the construction manager approach to building and he felt a good bonus clause in the construction contract would have a higher payoff. As far as government contracts are concerned, Mr. Loomis believes that "advertised bidding" invites problems and that bidders should be selected. He felt that quality is largely a matter of relationships between people. Everyone makes mistakes and therefore intermediate checks and verifications are needed.

On licensing, Mr. Loomis did not think taking university courses and getting credits would have much impact because the subject matter may be too varied relative to the next project. He felt that "the concept of continuing education is excellent and all good engineers must be involved in it every day. We learn as we work, we read the journals and we talk with others in our field. It is a mistake to consider that a classroom or a formal course is necessary to the process of education. The attempt to require a practicing engineer to gather course credits in order to renew his registration may be very good business for those who teach the courses, but it cannot improve the quality of engineers. It becomes another of the games we play to around authorities who would treat us all as children. I take the courses that apply in my field, but my engineering cannot be helped by taking courses in business mangement or other peripheral subjects. And it all reduced the time that I can devote to the things that I know should be done."

Discussion with Dr. Charles Thornton, Lev Zetlin Associates—February 10, 1982

Dr. Thornton was anxious to give his impressions of the underlying causes of structural failures although he was not at all sure there was an increasing trend in such failures. In fact, Dr. Thornton stated, "There may be less structural collapses today than there used to be." The media may have an influence on what is perceived to be an increasing trend. It is, in Dr. Thornton's opinion, unethical for an engineer to hypothesize on the cause of a structural failure when he was not personally involved in an investigation of the failure.

Dr. Thornton believes that the education is better today than ever in good engineering schools, but there are many mediocre engineering schools. However, he also believes it is easier to get through engineering schools today and only 120 credits are generally required as opposed to 160 credits years ago. Many schools are only able to maintain their operations by keeping tuitions up while reducing credit hours. The quality of engineering graduates from good engineering schools is better than it used to be. They are generally brighter, more aware and more interested, and they are better qualified to use computers. However, they are not well-educated in the properties of materials and the effect these properties may have on structures. He also noted that since the Vietnam era, the engineers have a better work ethic. Dr. Thornton believes in the use of computers saying that they assure consistency between engineers, tend to make the calculation process more accurate, and eliminate errors. There is also more opportunity to check the work.

Dr. Thornton stressed the importance of continuity of personnel on the job (meaning especially during the design phase). He believes, that continuity from concept through schematic drawings, design, preparation and contract documents, shop drawings and construction is paramount. He said, "If you have multiple people on the project, you introduce opportunity for structural failure." To achieve this, you have to keep engineers motivated and decrease personnel turnover. An example of how to introduce the potential of having a failure is to use one company to design the facility, have the owner/developer get another company to check the shop drawings, and a third firm to perform field inspection.

Dr. Thornton felt the Federal Government loses money on most of their projects because of what he calls the "procurement syndrome." He notes it is 50 percent to 100 percent more costly for government engineers to inspect construction than it would be for private design engineers to perform the work. While private design engineers are frequently "on-call" on government projects, they are seldom called. New York City has controlled inspections where either the design engineer or another professional engineer must inspect construction. All concrete and steel work must be inspected. Municipal building departments cannot adequately check shop drawings.

In discussing the impact of "fast-track" project management, Dr. Thornton mentioned that it "puts more pressure on the design team, but experienced people can handle it."

The advantages of "fast track", of course, is that if managed properly, it will reduce the overall project costs. Bally's Casino in Atlantic

City, a $214 million project, was completed in one year and two months from design through construction. The project necessitated rechecking as the design evolved, to incorporate needed functions. Generally, some additional safety factor is incorporated in the design and it is sometimes necessary to double back and reinforce certain parts of the structure to accommodate a loading not identified at the outset of the project, but it saves time and, with the interest on borrowed money at 16%, it is worth it. On Bally's, the total schedule reduction was between three and two years.

Dr. Thornton praised the universities in doing excellent work in their testing laboratories. In particular, he applauded the Colorado State University at Fort Collins wind tunnel facility.

The use of non-engineers for construction inspectors was criticized and he specifically mentioned one case of an unemployed history professor who certified that all structural members were straight and true on a project which later collapsed. The City of Los Angeles permits the use of paratechnical people as licensed deputy inspectors. They must, however, report to the City Engineer even when engaged on privately financed construction work.

Dr. Thornton mentioned that builders do not cheat on structural work by watering the concrete or downgrading the size of members. When something is not done properly, it is out of stupidity, not intent.

He also feels that owner/developers should not permit the architects to select the structural engineering firm. They should realize that the structural engineer will typically receive six percent of the architect's fee for doing 18% of the work. Competitive bidding between engineering firms leads to "low-balling" bids which can lead to structural failures. To minimize failures, it is necessary to pay extreme attention to details. It is necessary to brainstorm the project, to think and review the work, and the magnitude of this effort cannot be judged accurately by a reviewing committee. Dr. Thornton likes the Brooks bill (P.L. 92–582).

On highway bridges, Dr. Thornton pointed out that some steel companies are overselling their produce and tend to minimize the ductility problem. Older engineers, he says, will not allow welding to the tension flange.

Most structural failures are in secondary systems, like the framing which carries facades.

Some manufacturers fail to notify architects and engineers when they make changes in the chemistry of their materials. This happens with roofing materials.

Dr. Thornton also mentioned California's separate licensing for structural engineers. He does not favor recertification of engineers however. He does favor continuing education and the use of CEUs (continuing education units).

Discussion with Severud, Perrone, Szegezdy and Strum—February 10, 1982

A meeting was held with Mr. Alfred J. Perrone in the morning to listen to the firm's impressions of building failures and their recommendations for improvements in the industry. A letter was prepared by Mr. Tibor Szegezdy.

Mr. Perrone mentioned the Brooks bills, P. L. 92–582 as being a good piece of legislation. They believe that engineering work should be awarded to firms based on qualifications—not on price. Mr. Perrone felt that the government should not "shop for low fees."

In general, he felt that government building departments were not able to add anything in the process to promote quality. Reviewing unknown engineering work was of little value. At one time, the engineers in these departments were making more detailed reviews than they presently do. They also do not have any legal responsibility.

Another comment, heard more than once, was that recent engineering graduates are too computer-oriented. Along with this, it was felt that the schools are not teaching enough detail design.

Another subject was the structural engineering design fees. These fees are too low to allow for sufficient time, and, therefore, engineering reverification.

Mr. Perrone mentioned that some of the newer designs were "first of kind" and therefore were not supported by previous experience. For such designs, there is the need, nonetheless, to keep costs from escalating. To accomplish this during the design phase means that the redundancy has to be considered carefully, for there is little margin for "overdesign". Also, the people on the project may have little experience with some of the newer connectors and high strength materials. This can lead to failures if the project is not managed properly. For example, with high strength reinforcing for concrete, the quality needed may be less, but precise placement is more critical. However, many construction contractors continue to use the same methods they used 20 years ago. Higher strength concrete necessitates greater care in handling and placement and better control of the mix. The use of newer high strength bolts results in fewer bolts per connection. However, this also means that the contractor has to take more care in placement and tightening (torquing) these bolts.

The use of non-professional engineers and even personnel without engineering degrees in design work can result in failures. Particularly in steel construction, many so-called shop drawings, which contain much of the design detail, may be prepared by sub-professional people. If the steel fabricators do not use a qualified professional engineer who can spend a lot of time checking these drawings, there is opportunity for a failure. Details are important.

In New York City, the design engineer must check the construction work in progress, which uses controlled materials. However, the owner can retain a separate engineer for this purpose, but the design engineer has to approve his qualifications.

Severud and Perrone train their own engineers, most of whom stay with the firm for 15 to 20 years. Structural problems are more apt to occur when an unqualified firm or weak design team are assigned to the job.

At times, a construction contractor will make changes on a project and "do it his way". Leaving certain features out or changing the spacing between members happens.

Throughout the United States different building codes apply to similar work and some of these codes are not strict enough.

Mr. Perrone did not believe more research or testing is necessary for the current structures. He said, "If anything, there is more research

data available than can be digested." None of the recent failures could have been prevented by more research. Research may even be driving the art too fast; it may be going in the wrong direction at this point in time.

The firm believes separate peer reviews on complicated structures would be beneficial, but then, too, engineering firms should be given sufficient fees to enable them to spend more time checking their own designs.

Certificate of occupancies could be beneficial provided it was passed on to future owners by deed and provided it contained limitations on the use of the buildings.

Discussion with Dr. John Hanson, Dr. Robert Crist and Mr. Don Pfeifer, Wiss, Janney, Elstner and Associates, Inc.—April 14, 1982

The meeting was held in the firm's offices in Northbrook, Illinois. Wiss, Janney, Elstner and Associates, a 25 year old firm, is engaged in investigating structural failures and designing corrections to correct structural deficiencies. They have an excellent structural testing facility located adjacent to their offices. They were readily willing to discuss their feelings about structural failures and how they might be minimized.

Dr. John Hanson feels that there is less cooperation between engineers and construction contractors than 20 years ago, and that this leads to oversights that may cause failures. He points out that construction documents are never perfect and construction contractors will look for deficiencies in order to develop claims against the owner/developer. At one time, contractors may have made corrections in the field without submitting claims, but that is seldom true today.

The industry is more fragmented today. Construction contractors depend more on specialized subcontractors and they use more specialized construction equipment. Most construction contractors now have smaller organizations. While this results in cost savings, it also increases the number of interfaces between various organizations. Construction management teaching programs are lagging behind what is required to deal with the complexity of today's construction projects.

From their experience, the use of a construction manager as opposed to a general contractor (construction company) is usually not as satisfactory, since the projects are seldom staffed by well qualified people.

Dr. Robert Crist questioned "who is responsible for what? Insurance companies are involved in construction projects, oil companies, state and federal agencies! Who controls the quality?" Municipal building departments cannot be counted on to control quality through their inspections.

Mr. Don Pfeifer mentioned that many owners are not willing to pay for on-site inspection during construction and it's not clear where the responsibility lies. John Hanson felt the owner is responsible for controlling the quality of the job and the Architect/Engineer should advise him of that fact. The owner may not realize the extent of the risk. The required amount of on-site inspection varies with the complexity of the project.

They felt there were both design faults and construction faults in the industry which lead to failures. Even if the structure were not to collapse, if a building could not be used for its original intended pur-

pose—that would constitute a failure. Today, the framing systems are more complicated. They are no longer designed solely for load and stress. Some designs are based on deflection and vibration frequencies.

We spoke of the findings on several recent building failures, most of which were the results of design faults. Quality control is important during the design phase. There are many pressures on the design team to "get the job done." The engineers must be adequately paid to get a quality job. Some engineers, perhaps too many, accept risks that they do not understand. John Hanson felt the quality of engineering is more dependent on the standards of the design firm than on professional engineering licensing procedures. John is on the Illinois licensing board and he reviews applications, but he does not feel the licensing procedures are very effective. Many firms operate nationally, yet the licensing, is by individual states for practicing within the state. There is a National Council of Licensing Examiners who have been working on standardization. Dr. Crist believed a national test would be good.

We then discussed design for seismic conditions outside of the California area, since California gives seismic design considerations a great deal of attention. John Hanson felt that more attention should be given to design provisions for earthquake resistance. Some new building codes are addressing it. Older buildings of about 10 stories in height built during the 1930's and 40's are more susceptible to damage than the new, higher structures.

Technology is leading the ability to utilize it, although Europe and Japan are doing more than we are in the U.S. We have reached the point where we can analyze anything with a computer. Some engineers, after analyzing a structure, believe everything has been solved—but the structure may be one that can't be built.

Virtually every failure occurs at a joint (connection between members) and this is something that cannot be easily modeled. The work is left to a detailer. This portion of the work is "engineering art" and John Hanson feels this is being lost. He worries about craftsmanship as applied to joint details. Bob Crist feels more skill is required to understand elastic behavior in new materials—something which can be modeled. The joints must be "buildable" for if they are not, construction trades will make changes in the field on their own and the joints may fail. Components have to fit together.

Many engineers applying for licenses in Illinois are not U.S. citizens, which can lead to communication problems during the course of a project. Many universities have professors who are foreign nationals and many of them are theorists without practical experience. U.S. undergraduates are prone to leave the universities and take good paying jobs before obtaining an advanced degree. Only 4 students in metalurgy at Champaign-Urbana are continuing for advanced degrees. The foreign influence in the field is having an effect. While the foreign engineers are smart, their aptitudes are focused in specialties and this may not meet all the needs of the building field. We may be training engineers at a higher theoretical level than can be used for most projects in the industry.

When asked about particular design problems, John Hanson said he foresees problems with welded steel bridges. Most structures are

stronger than believed because of redundancies and load redistribution. However, where there are sustained high dead loads in tension there is reason for special concern.

Discussion with Sherwin P. Asrow, S. P. Asrow Associates, Ltd.—April 15, 1982

Mr. Asrow was specific in his comments. He believed the Architect/Engineer should control a project. He believes the design professional should stay involved throughout the project and advocates greater communication between engineers and builders. He notes however that engineers want to pull out of the project after the design has been completed and that they will not visit the job site. As soon as an engineer visits the job site he becomes liable for anything that happens whether he is directly responsible or not. Therefore, the builders who do not go to the designers for clarification are the ones who get in trouble. What he is really looking for are some guidelines for the professional engineer to follow without putting him in a position of liability. Mr. Asrow mentioned one project where workmen were killed during construction because of lack of guidance to the builder from the designer. OSHA does not help—it is an "after the fact" organization. They cannot handle the technical preventive work.

On government work, Mr. Asrow notes that the specifications are so difficult to achieve, that it forces him to do work at above normal expenses. A professional must be allowed to do a cost-effective job.

When a contractor submits a bid on a project he should also submit the name of his engineer with his proposal so he can be evaluated. The Chicago Tunnel project bid specifications required the contractor to hire a professional engineer to oversee the bracing work. The designer cannot detail everything, so the contractor needs a professional engineer on the job. Many contractors only see the professional engineer as a "sounding board" who puts his name on paper, but one who does not do the design details. This could lead to structural failures.

Mr. Asrow does not feel the colleges are instilling professionalism in their students. He suggests a survey of universities to determine how adequate the teaching may be. He doesn't believe the universities have the dollars to attract experienced professional design engineers as professors and believes most professors have not had experience in private practice. Students must not only learn engineering but should learn the total construction process as well.

Licensing may be more politically oriented than professional, but it should be possible for a PE to practice in any state. State licensing limits flexibility.

Relicensing of engineers would be a hardship because the exams go into extreme detail in so many areas, engineers can't pick it up. (Editor's note—Licensing examinations include complex questions involving calculations in technical areas over a broad spectrum of subjects. Generally engineers in practice work in a more limited range of subjects and lose their ability to resolve a problem they haven't worked for years. For example: a competent structural engineer may not have worked a hydraulic problem for 15 years). Mr. Asrow did feel that continuing education and oral examinations are good because it still makes the individual "step up"—it protects the public by putting the engineer on notice of his liabilities.

Mr. Asrow believes government construction contracting procedures result in numerous legal claims submitted by contractors. Officials in the public sector are forced to accept the low bid which may be below what it costs to do the job. A better system would be to take the 3 low bidders and have a professional engineer review their qualifications and select a winner.

Wind forces on building structures were discussed by Mr. Asrow. He mentioned a proposal, submitted 3 to 4 years ago to the National Science Foundation for studying the effects of wind currents and forces for the city of Chicago. He pointed out that the entire city has to be studied because of the interrelationships between structures. A new building for example could alter the forces on an existing building. Building codes may not be adequate and developers may be proceeding without adequate design data. Mr. Asrow believes that Canada is ahead of the U.S. in this area and he mentioned work done by Professor Davenport at Ontario University on wind and earthquake loads and public risk. Mr. Asrow doesn't think all the research can be done in academia however and he believes some of the work should be done by design professionals.

Discussion with Mr. Shankar Nair, Alfred Benesch & Co.—April 15, 1982

Alfred Benesch & Company is a 100 person engineering firm specializing in structural engineering for buildings, railroad bridges and highway bridges.

Mr. Nair was not sure that there was an increasing trend in structural failures. While there have been some catastrophic failures recently, this does not necessarily denote a trend. However, conditions are developing that could lead to a greater frequency of failures.

He noted that there is an increasing lack of communication between the various disciplines involved in the construction industry and that this sometimes leads to design being done in the field by an unqualified party. There is often no clear cut division of responsibility between architect, structural engineer and detailer and sometimes improper details get through the system.

Engineers become nervous about getting involved in field construction. With today's potential for a lawsuit, if an engineer merely visits a job site, he is susceptible to being sued in connection with occurrences over which he has absolutely no control. Mr. Nair said engineers should insist on being named in the construction contractor's insurance policy for protection against nuisance claims. The legal liability factor makes engineers shy away from taking on any unnecessary obligations.

The providing of engineering services for public works projects is becoming more and more competitive. The "Brooks' Bill" (Editor's note—Public Law 92-582) helps but it does not go far enough. Competitive pressure force engineers to do no more than the minimum in exploring alternatives and developing designs and details. While this might not directly result in failures, it will cause a general reduction in the quality of public works projects.

New materials lead to pushing the design limits. For example, in high strength concrete, normal practice has moved from 3,500 psi (pounds per square inch strength) to 7,000 psi in 20 years. The higher

strength concrete can be used safety, but require special expertise on the part of the builder to maintain quality control in the field. (Editor's note—where the final product is made). Newer steels have higher yield points, up to 100,000 psi. 50,000 psi is now common whereas 36,000 psi was common 20 years ago. This however requires special expertise on the part of the design engineer as well as the builder. The high strength steel can be used safely but requires special care in design, detailing and handling. High strength steel is susceptible to failure if details are not developed with special care or if it is cut or welded improperly in the field.

Mr. Nair feels quality control of transit mix concrete is adequate, at least on large projects that are subject to inspection and testing by representatives of the owner. When questioned about the need for inspection, he replied that he doesn't understand how a construction contractor can realistically inspect his own work. Some degree of independent inspection is necessary.

Professional engineers' licensing procedures were discussed. Mr. Nair felt that a license can create an illusion. A general Professional Engineer's license is not enough for a structural engineer and States should require separate structural engineering licenses, as does Illinois. The examination for this license takes two days to complete and is specifically for structural engineers. He also believes that retesting engineers is a good idea but feels the way it is done is weak.

Mr. Nair does not believe that builders will deliberately cheat on structural work. He says, "it is too easy to get caught and too expensive if a problem develops."

He believes sufficient data is available for engineers to do quality work. There is no deficiency in research and development. He also believes that scale models will benefit design refinements, but will not make a structure safer.

The discussion moved to the competence of engineers. Mr. Nair felt strongly that the newer graduates are good, better than three to five years ago based upon the same schools, and he does not feel they put too much reliance on computers. His philosophy is interesting. He doesn't expect recent graduates to have a "feel" for the overall quality of a structure. He has recent graduates do apprentice work for two years or so and expects them to gain more appreciation for the total workings of a structure later on, saying, "you learn with practical experience." A problem in engineering, he says, is that success is measured in terms of getting out of it and moving into management. As a result, the most competent engineers are not doing engineering; they have become managers. There is insufficient incentive for engineers to develop their skills as engineers.

Mr. Nair did not believe enough attention was being given to incorporation of seismic provisions in projects outside of California, although he thought there may be some overkill in California. He mentioned that the 1812 New Madrid earthquake, in southern Illinois and Missouri, near St. Louis, was the worst in U.S. recorded history.

Discussion with Jack D. Gillum, Jack D. Gillum Associates—April 16, 1982

Mr. Gillum had given the subject of structural failures serious thought and had many points to make. He spoke of time constraints

and dollar constraints imposing on construction and design quality and he worries about division or responsibility between designers and others involved in the construction. Specifically, he mentioned that some developers want everything for nothing.

Mr. Gillum said there are differences between what an engineer is contracted to do and what the public assumes he is to do.

Jack Gillum believes the State registration boards are doing a good job. He notes that engineering is a specialized profession, however, and that Illinois, Arizona, Washington, Kentucky and California all have separate licenses for structural engineers. He worries about the right of one engineer who can legally "stamp" (approve) structural, mechanical and electrical drawings. He also believes that most engineers would now welcome peer reviews of their work in order to provide better assurance of quality.

In discussing Federal Government procedures for design and construction of facilities, he believes that responsibilities were better defined but he noted that different government agencies administer contracts in different ways. In general, he felt that bureaucrats believe their job depends on negotiating the architect/engineer down to the lowest dollar without any thought about the effect this might have on the project. He also mentioned that many Federal engineers are not technically "up to date". Time and material contracts, he feels, generally create excessive loading of people on the job without materially improving quality.

Jack Gillum thinks recent engineering graduates are well-trained to perform mathematical calculations, but that they are not particularly qualified to do practical design work. Certainly they would have little practical experience to guide them, but he also believes some of this problem is created by college professors who also have not had practical design experience. He noted that only about 25 percent of the Technical Advisory Committee of the AISC Manual of Steel Construction were "practicing" engineers.

Mr. Gillum does not feel that anyone is really looking into quality control on projects from design through construction. Ernie Brown, who works for Jack D. Gillum Associates, feels that competitive bidding between engineers limits the quality—but owners feel this is the way to get the price down.

Mr. Gillum had to leave the meeting and Daniel Duncan, Vice President of the firm and Ernie Brown continued the discussion. They noted that structural engineers tend not to share their project experiences.

Construction managers, as opposed to construction companies, do not take over the role formerly provided by architects. (Editor's Note: At one time in history, architects were the "captains" of the project, not only in terms of design, but also, they were the builders who knew how the facility had to be constructed. They were accountable for the results. Later, the architect traditionally concentrated on design, leaving the construction to a firm who had the experience, equipment, stock of basic materials, and employees to build facilities. Construction managers, however, frequently have no skilled construction laborers, or equipment, or materials.) The construction managers frequently only coordinate the subcontractors and do not participate in the design or quality control.

Mr. Duncan and Mr. Brown went through a list of their concerns:

1. Testing laboratories, which verify the strength of concrete and placement of reinforcing steel in the field are not responsible for things they don't catch.

2. Structural engineers may or may not have periodic construction site visits written into their contracts and they are rarely assigned to construction projects.

3. Structural engineers may or may not design the details for structural steel connection.

4. Computer analysis of structural systems enables engineers to reduce construction materials safety factors. While reductions in construction materials generally reduces cost, the risk is increased. This also leads to a greater need for quality control. Also, any mistakes made in the field can have a greater impact. For example, in concrete structures with less materials, there is greater dependence on the placement of steel reinforcing.

5. In the beginning of a construction project, that is, during construction of the foundation and superstructure, you really do need a structural engineer on the job, not an architect. The need for an "on-site" architect is usually more significant after the structural work has been completed.

6. They wondered if a law which would require owners to have a structural engineer on site during construction with the authority to assure immediate corrective action of unacceptable work would be practical.

7. A structural engineer on site would need to be protected from certain changes by law. For example, should a structural engineer witness work that was unacceptable and should he then stop the job. The construction contractor would seek reimbursement for his losses resulting from idle labor and equipment. This would be even more critical during this period of high interest rates.

8. The structural engineer has little or no contact with the owner since he is actually a subcontractor to the architect.

9. At one time, architects, or their structural engineers, did the entire structural design. Now an important portion of this design, the structural connection details, is left to a steel fabricator. The fabricator generally has an engineer as well as other specialists on his payroll and he is more familiar with shop fabrication processes, including economies of fabrication. However, even though it is recognized that the fabricator is responsible for connection details, he believes he is relieved of accountability after his "shop drawings" are approved. This belief is based on the latest AISC Code of Standard Practices. Mr. Brown pointed out that the real purpose of a shop drawing is to enable the people in the shop to do the fabrication work, not to relieve the fabricator of responsibility for his work. It is Mr. Brown's opinion such drawings should not be reviewed by the structural engineer.

10. A similar situation exists with precast concrete fabricators who would not want an outside structural engineer to design the precast units. In these cases, only the design loadings (performance specifications) are forwarded to the fabricator. Fabricators, therefore, should be responsible for submitting drawings with a

professional engineering (PE) seal. Such a certification should then relieve the structural engineer of responsibility for this portion of the work. With fabricators doing some of the design, owner/developer costs are less.

11. The structural design is probably the single most important aspect of design relative to public safety. In spite of this, the scope of services and fees are quite limited. (Editor's Note: Total amount of contract, not just profit). The standard fee paid to structural engineers is considerably less than other fees paid for substantially less important work. An example would be the architect's fees on a $36 million public building. This would generally amount to something in the order of $1.8 million (5 percent). The architect's fee would include the structural engineer's fee which would be about $270,000 or less than 1 percent of the total. Many owner/developers believe that limiting the structural engineering services hence lower fee is good business, but they would not hesitate paying a real estate broker five times that amount for bringing in a buyer when they decide to sell the building.

12. They believe you have to get to the owner/developer and convince them to contract the structural engineer for an expanded scope of services that would include all phases of the project not just a limited design/contract document phase. Also allow more time for the design and development of the contract documents.

Discussion with William H. Dunn, J. E. Dunn Construction Co.—April 16, 1982

Mr. Dunn was very cordial and interested in participating in the inquiry on structural failures. He began by pointing out that many owner-developers are not sophisticated. He believes that they should retain well qualified architects and engineers. He also mentioned that the duties and responsibilities of all participants in a project must be clearly perscribed. Mr. Dunn worries about such things as owners who restrict fees for design, do their own structural engineering with unqualified people and fail to obtain proper soil samples. He also feels some architects pay fees for engineering which are too low.

Mr. Dunn feels that the inspection and quality control on projects is insufficient. With regard to design, he notes that there have been times when a construction worker discovered design deficiencies. He also believes that the design engineers should be on site during construction of structural work and is aware of the fact that they are frequently not allowed to visit the site. An independent engineer on site is not as good because of his lack of familiarity with the design and with the whole picture.

Many designers do not have in-house laboratory capability for such purposes as welding tests and non-destructive tests. When such tests are done by independent laboratories, it would help the contractor if he received guidance from the designer.

Building codes only set basic parameters and the people who are responsible for their inforcement can not detect design flaws. Public building officials cannot hire the level of talent it would take to adequately review structural designs and it is doubtful that they would even catch improper construction methods.

It is up to the builders to design their own concrete formwork and shoring. Bill Dunn uses professional engineers for this purpose.

With regard to design details, the engineer he says, "can't do all the design". Many times the details are left to the contractor and the fabricator. The fabricator will make shop drawings of joints, but it is doubtful that these drawings will receive adequate review by the fabricator or design engineer.

Bidding on construction projects is an endless problem, especially government projects where anyone can submit a bid as long as they secure a bid bond. Design engineers should participate in the selection of the contractor, not every construction contractor has the same degree of expertise. Mr. Dunn cited an extreme case of a construction contractor from Missouri who submitted a low bid on five jobs in California. Then his attorney submitted requests for time extensions. All he did was erect a fence and put an office trailer on each job site.

Owner/developers work to meet budgets which may be established too early in the project. (Editor's note—meaning they then have to take short cuts and hold down procurement costs). Some money can be saved however. For example, there is nothing wrong with buying a 2 year bond on roofing as opposed to a 15 year bond. The cost will be less and if the roofing is bad, it will show up in the first year anyway. The attitude of some owner/developers is changing somewhat however, at least in negotiated contracts.

In the past 10 to 12 years technology has changed the construction industry. Climbing cranes, pumped concrete, on-site radio communications, and computer aided structural design. However, exotic designs can still lead to safety and quality problems.

Fast track construction management can lead to problems if it is not carefully executed. The design documents must be good enough to obtain competitive bid with and the design engineer must follow up with additional documents in a logical sequence. The fast track method can't accommodate gaps in the construction work. It requires extra work but it is a great vehicle for saving dollars. The construction team of owner, designer and contractor on the job must be competent.

The construction manager approach to construction can be good or bad. If the owner wants a broker it can be bad. The construction manager should have some project responsibility and especially for safety and quality control.

Individual duties and responsibilities must be carefully defined on projects. Mr. Dunn emphasized that construction is a high risk industry. He has independent professional engineers review structural design and they find many "near misses". Sometimes he finds design work is given to the inexperienced engineers. He finds items like omission of shear walls— and he advocates more intense monitoring and review of design by all members of the construction team—owner, designer and contractor.

Appendix B.—Excerpts From Replies to Questionnaire to the Construction Industry

During the course of the investigation, the Committee has compiled a set of 22 questions which potentially pertained to structural failures. To further extend its base of information, the Committee mailed these questions to over 350 firms related to the construction industry. Industry's responses to these questions follow. They are listed first, by one of the 22 questions, and secondly by group, such as architects, engineers, construction firms, construction managers, state and building officials, owners, developers, banks and financial institutions, and insurance companies.

1. COMMUNICATIONS AND ORGANIZATION

Are most projects organized in a manner where all parties know their specific responsibilities and where they interface with other parties?

Are communications between owner, developer, architect, structural engineer, and builders usually effective on most projects or are they infrequent, uninformative, etc.?

a. Architects

"In recent years, however, we have experienced several instances where these standard documents have been modified by Owners and/or Developers to the extent that the Architect's duties, obligations, and responsibilities have been subordinated to the Owner and/or Developer with respect to the Architect's interpretive powers, decision-making authority, and independent arbiter role."

"Communications are usually effective if at least one of the listed parties insists and follows through on them. In our case, we find that communications are usually effective only when the A/E (us) insists on them."

"This should be *all* projects. *Every* project should have a written contract and the responsibilities of each should be clearly defined."

"A fertile field for misunderstanding."

"Communication between client, Owner or developer, the design professional and the contractor is most essential for the successful realization of design and construction of any project. Without such joint participation, performance of the most capable participants leaves a lot to be desired."

"In cases where parties do not fully know their specific responsibilities and do not interact with others, the result of their performance becomes, generally, suspect."

"If the A/E uses an outside consultant, the coordination and omission of errors becomes more difficult to control. We have in-house structural, mechanical, electrical—."

"Small projects—under $500,000.00 seem to get by with less checking. Larger projects with insufficiency. Time to complete working drawings and *check* them w/s.e. is sometimes the cause of major structural errors."

"Over the last several years we have seen a trend developing where some Owners and/or Developers are by-passing the Architect or Engineer and establishing direct communications with the Builders; the goal being to reduce bottom line cost and/or time required to construct the project. While we have not had an experience of this type which has resulted in any catastrophic circumstance arising, we have experienced problems and recognize that this type of action can: (1) represent an eminent danger to life safety, (2) result in a total loss of communication or miscommunication which could result in something being overlooked and last in translation."

b. Engineers

"This is a function of the management ability of the prime professional and his area of greatest interest. For example, architects are "creative" people and are not, as a general rule, managerially-oriented. For dealings with most small architectural firms, we normally recommend to owners a separate prime engineering contract rather than the traditional prime/sub role."

"This is a function of management ability but the discipline of the engineering profession tends to make such interface a rote process. Recent DOJ and court rulings against such disciplined approaches and recognized professional ground rules for operation, damage the system and we believe, will lead to disruption with unpredictable results."

"Many projects go from developer, through architect-engineer, and then to the builder. Some developer-builders make revisions without architects' knowledge. Design-build projects without an independent check are vulnerable to problems."

"Only solution is to establish one party having clear responsibility for structural integrity."

"The parties generally know their specific responsibilities, but they often give the highest priority to doing their work efficiently and quickly; place low priority on how their practice affects the other parties and give little attention to the impact on the structural integrity."

"On major projects we require monthly meetings of the entire team. Bimonthly meetings held between the A/E and Builder/Contractor."

"It is difficult to generalize since clients work differently. There is no uniform procedure. It often depends on the individuals involved."

"With complex projects, there are always grey areas of responsibility. The most effective way of preventing problems in this area is to have someone responsible for the entire project and this individual work out the grey areas as necessary."

"There is a clear delineation of responsibilities between structural and other disciplines."

"Essential information transfer is effective between designers and constructors."

"Due to the cost of litigation and the high liabilities associated with design, most parties are well aware of their specific responsibilities and want to limit them."

"The information needed by the structural engineer generally requires minimal input from the owner or developer. The more intricate the project is, the more cooperative effort is required between the architect and engineers. The builders' opinions are valuable in finding the best way in the field to achieve the desired result but too often contractors do miss the point and simplify the construction regardless of effect."

"This depends upon the individuals involved. Communications are the responsibility of our project managers with the level of effort necessary directly related to the clients' recognition of the need for good communication and the part it can play in a successful project."

"This, as with communications," is directly related to the sophistication of the client. Private clients, especially industrial, usually exhibit better organization than government with municipalities often having the least effective organization."

"Communications among the consultants for proper coordination of the project and between the consultants and the builder for eliminating chances of misinterpretation are an essential element in the successful completion of a project."

"Project organization, from design stage through completion of construction, generally determines the success of the project by ensuring smooth interface between the parties involved."

"Communications are important, can often be improved. Need system to assure they happen. Sometimes lacking due to personal inadequacies."

"Important to have meetings to discuss responsibilties, overlaps, interactions, understanding of duties."

"Communications are delayed. Architect keep refining design—introducing owner changes and information gets to engineer late and inadequately defined."

"However, very often owners do not know and balk at requirements such as engaging testing laboratories, etc; such requirements should be incorporated in building codes."

"Effectiveness very dependent on client and the engineer. I'm not sure the current trend of many clients doesn't go too far to the point of being cumbersome and time-consuming."

"This entirely depends on the client/owner. We as structure consultants to architects have a variety of clients and circumstances. Communications always are through our clients, who have varying policies. Very good to horrible."

"Organization of definition of responsibility are not always clear for everyone."

"For most projects, I believe effective lines of communication are maintained."

"My experience has been that the participants in the design and construction effort usually know and understand their responsibilities. Many times, because of budget restraints or for other reasons, members of the design team are unable to exercise their authority to the degree that is appropriate."

"The concept of a team effort has become such a sales tool for architects that they overdo it in execution. A good structure requires concentrated individual effort. You must think carefully about how it might fail and not miss the weak link. Meetings, conferences and constant revisions make such concentration difficult."

c. Construction firms

"Communications between Owner and Architect and Contractor are for the most part, effective. The structural engineer does not get involved in verbal communication unless a structural problem arises. The written communication from architects and structural engineers is usually effective."

"I think the organization between architects, structural engineer and contractor is well-organized on most projects. However, organization of the owner and his specific responsibilities is not always well-defined."

"Most owners we have worked for recognize the importance of scheduled meetings involving all parties."

"Depends on type of project. On Design-Build projects, communications are very effective. On competitively Bid-Lump Sum Contracts, communications are infrequent and ineffective."

"With regard to specific responsibilities and interface with other parties, the contract documents spell out the relations."

"Depends on quality of General Contractor/Architect to manage and control."

d. Construction Managers

"For design build firms communications are especially effective."

"This is especially true for design build firms."

"In the process of construction management, these pre-construction communications are extremely important and frequent."

e. State and Building Code Officials

"For example, floor loadings are discussed among owner, tenant, architect, structural engineer and contractor to gain full understanding of intended and possible usage."

"The large, new office building projects have good direction as to responsibility. The remodeling projects are sometimes confusing."

"Communications of this nature are absolutely necessary. If there is a breakdown in communications from the drawing board to the ribbon cutting ceremony chances are that there will be significant problems. Constant, effective communications will minimize problems."

"The State of New Jersey is demanding a more precise description of the scope of the work prior to engaging an architect. Once the architect has been selected, coordinated meetings are held with all parties to most effectively develop the project. On complicated or larger-sized projects, pre-bid meetings are scheduled with architects and contractors to facilitate responses to questions."

"In dealing with architects, structural engineers, and for the most part builders, the communications are usually effective. The communications with owners and developers are not as effective. As a rule owners are not knowledgeable enough about construction standards

and therefore can be very difficult to deal with. In our area owners are allowed to design their own buildings, even though they are for public use."

"Those projects prepared by licensed designers are for the most part well-organized. Those not prepared by licensed designers, which is the bulk of our work, are very difficult to follow and to obtain compliance."

"Architect should see that communication between all involved is clear."

"The project design team leader (architect or engineer) should see to proper organization."

"Communication between the various parties is of utmost importance. However, authority or 'chain of authority' must be adhered to."

"Our building official is an only link to the communications process which goes on during a construction project. Good communication between all parties on a construction project is essential to both quality and economy. Generally the larger the construction project the more complex the communication system."

"Many parties to construction projects are less aware of their responsibilities and liabilities than they should be."

"Certainly communication between the contractor, engineer, architect and the building department responsible for issuing the building permit is absolutely essential if the structure is going to be constructed as it was designed and approved."

"During both design and construction, the Board acting as the Owner maintains constant liaison with the architect and the contractor. Structural matters are submitted to the architect for consideration by his structural engineering consultant. State architects, engineers and construction inspectors are designed to the project."

"The Board administers the project through the design architect and holds him responsible for all engineering. During construction all matters affecting construction or the contractor are administered through the design architect."

"There are times that the architect does not convey all information to owners."

"With the lack of 'one stop shopping' there are voids in the state regulating process."

"We can only know they come to us as a team or group. Most of the time we must request additional information from one of the group at left."

"Although most projects are organized with respect to their specific responsibilities, there is often confusion with respect to interfacing with governmental and regulatory agencies. This is true particularly with respect to 'who' and 'how' regulatory agencies are involved."

"Standard Contract forms are utilized on all state projects. These contracts outline the responsibilities of each party involved with a particular phase of the project."

"The organization is the contractor's responsibility within the limits of the bidding documents as prepared by the consultant in concert with the owner."

f. Owners

"In work performed for the West Virginia Department of Highways, communications are constant and are usually effective."

"In our work, we feel projects are fully organized through all phases and that responsibilities and authorities are understood."

"Communications between GSA (owner) and architect/engineer (A–E) are frequent and reviews at various stages of design help to keep the communications open."

"Interfacing occurs between all disciplines within the Design and Construction Division; however, A–E contracts are normally with one firm who is charged with the responsibility of assuring that interfacing occurs between their consultants."

"Sometimes less so with developer clients, especially those who do not intend to use architects or engineers to perform inspections during the construction phase, i.e., inspection is left to the owner or contractor."

"The contract plans and specifications must be complete, concise and clear. Otherwise, there will be a breakdown in communication."

"Communications may be improved through: (a) pre-bid conference when appropriate; (b) pre-construction conference; (c) Builder's Quality Control Plan; (d) Owner's Quality Control Plan; (e) Value Engineering concept."

"Only minor problems are likely to occur between the prime contractor and sub-contractors. Problems between owner and contractor frequently exist over the intent of the specifications rather than structural design."

"They are effective because we demand that level of communication."

"All communications between parties are effective."

"All projects are well-organized and responsibilities are specified clearly for all parties."

"On our projects Caltrans is the owner as well as the employer of the architects and engineers. Construction is done by private contractors."

"Compressed time frame because of cost considerations does not always allow for adequate communications."

"The Dallas/Fort Worth Airport maintains a strict compliance with established programming procedures from the start of the project through owner acceptance. It is our opinion that communication is of utmost importance as lack of communication is the primary cause if a problem does exist."

"Specific responsibility of all parties is identified as early as the contract negotiations between designer and owner as well as detailed in the programming stage of the project. Also, it is typical to have an extremely detailed specification instead of construction documents based on experience and use for each project type."

"Responsibilities are contractually formulated or defined by ordinance."

"The most effective means of controlling quality, safety- cost-effectiveness and time-consuming government permit processes is to rid of all government involvement in building and developing."

"Buildings could easily be overseen by insurance companies who would later be held responsible if anything went wrong because the

insurance company prematurely approved plans, or on-going construction; then that insurance company would be held liable. An insurance company certainly would not pass anything they felt would come back to them."

"The Navy has an excellent review system whereby the so-called 'customer' and the construction field office each has several opportunities to review and comment during project design on aesthetics, technical design aspects, constructability, site conflicts, maintainability, and so on. The designer maintains a continual dialogue with all applicable parties during project development."

"All projects are handled in a uniform manner and specific procedures are followed to insure continuity."

"Monthly job meetings are held for each project under construction and more frequently if deemed necessary."

"Contract documents clearly outline specific responsibilities for all parties."

"I haven't been involved a great deal with the communication line mentioned. I'm sure there are some disagreements among those involved but there is at least some communication. As far as I know the communication link on Corps projects is effective and also very essential."

"Applied to most Corps projects."

"Purdue has a very well-defined line of responsibility and communication."

"All projects are so organized."

g. Developers

"If the architect is superior he usually has control of the job. He coordinates his consultants (structural engineer, mechanical engineer, civil engineer, electrical engineer, soils engineer, etc.) to make sure that plans all are in conformance and that there are no errors or omissions and communications between architect and developer are clear."

"This usually depends on the team captain and his capabilities in organization."

h. Banks and Financial Institutions

"Normally only essential information is passed to the owner."

"This is the function of the project manager or general contractor or both. This coordination is normally quite good because it will effect the cost of the project."

"It is important that the owner insure that communication is frequent and effective."

i. Insurance Companies

"Our procedure has been to conduct planning sessions with the architect and the principal engineers which are involved in the planning of a facility. When the project is complete and let, it is our opinion that a weekly job site meeting is desirable in order that all involved; architect, contractor, owner, and principal subs are aware of the work which must be done and plans that are involved for each trade that is involved."

"We are of the opinion that on most projects the contractor and his principal subs are well aware of their portion of the work that they are to perform and through weekly job meetings have an opportunity to coordinate their work with other work that is being performed."

"We are currently constructing 5 buildings totalling approximately 2,800,000 GSF. Each utilize closely-knit project teams comprised of the owner (owner is developer), architect, construction manager, and structural MEP and civil engineers. All work very closely together. Meetings are as frequent as weekly but frequency varies over the life of the project—never less than monthly."

"Individual responsibilities are very clear and well-defined."

"Sometimes change orders, areas of concern, structural modifications may not get into writing or responses may not—do not become matter of record—later creates problems."

"Usually good as between owner, architect and structural engineer. Developer often involved in more speculative ventures where cost-cutting efforts during job progress lead to communication breakdown."

"It is essential that everyone do their part in keeping communication lines open and seeing that the necessary information is transmitted to all parties concerned."

"Our typical procedure is to meet not less than weekly on any project the company undertakes and each phase of development is reviewed by company staff, in preparation for said meetings."

"All projects are organized in a manner in which specific responsibilities are delineated. Including those of independent consultants."

"While communications between the various parties involved are almost always of an essential nature and usually effective, too often these communications break down, especially between the architects, structural and mechanical engineers. These communication breakdowns usually result in repairs or alterations to the structure at an added cost to the owner or developer."

"This communication should be set up as a regular part of the planning and construction phases of a development."

"This actually depends upon the technical expertise of the developer and professionals involved."

"This kind of communication is absolutely necessary."

"Ours are but I don't know about others."

"The owner/owner representative must usually request specific information or be knowledgeable in the industry in order to ask the right questions."

"Provided owner sets forth team guidelines for documentation/communication."

"Communications seem to be more effective when going the construction management route, as opposed to the traditional design—building—GC route. More team participation/interaction."

2. INSPECTION OF CONSTRUCTION

Should the project structural design engineer be on site during the construction of foundations, framing, etc.? Are structural engineers normally on site during such periods?

What liabilities beyond his control would a structural engineer incur by being on site?

a. Architects

"We live in an age of confrontation. Our court system and legal process is so antiquated that during the course of providing relief to one party who may have been damaged, many innocent parties who have been drawn into the case simply because they were there, sustain substantial loss in their defense without legal recourse to recover that unwarranted expense. The general thrust by the legal profession is to involve as many parties as possible, (the shotgun suit) charge contributory negligence, let the defendants get a feel for the expense involved in legal fees and time consumed in the preparation of the legal defense through the discovery stage, and ultimately propose a settlement which when divided by multiple defendants becomes less expensive than pursuing the matter to a conclusion in the court, but yet satisfy the plantiff's ultimate goal. This represents the best of both worlds to attorneys who do not lose a case and, therefore, suffer damage to their reputation, but yet provides substantial income to a great many lawyers who are involved in the case. Since our laws are unresponsive to the innocent people charged, there is a natural and justifiable aversion to becoming involved to any degree beyond that which is necessary and contracted for."

"It is not necessary for the structural engineer to be on site all the time, but he should be on the site frequently during construction of the foundations and framing."

"Not the point, it's his responsibility to afford the Owner his expertise in the field because of his Contract with the Architect or directly with the owner."

"We give a list of strategic visits that a structural engineer should make. This list is given to the Project Manager prior to the start of construction. We want the structural engineer to be there as they are starting each major component of structural work . . . such as foundations; first suspended slab; etc. Prior to first pour of concrete, he can instruct the construction administrator, or contractor, of any discrepancies, and give instructions for future work."

"There is always the possibility of litigation, but most problems are caused by lack of understanding, or misinterpretation, of design documents . . . or omission by just plain carelessness. The structural engineer can usually limit site visits to 3–5 trips on even large projects, where there is much repetition. This is not always the case, but mostly for buildings. . . ."

"Increase of his 'errors and omissions' liability. Most architects and structural engineers prefer calling their field trips 'contract administration' rather than 'supervision' for this reason."

"Structural engineers normally do not need to be at the site during construction, instead their qualified field representatives (structural, mechanical or electrical) are at the job site for the duration of construction to ascertain that design requirements (details and specifications) are fully carried out. Oversight or deviations in the execution of mechanical and electrical work can be equally critical and affect lives."

"The design engineer is responsible for the accuracy of design, whereas execution remains with the contractor. The presence of the engineer or his qualified field representative at the site does not bring on any more liability provided the design is correct. Under present-day

circumstances, in case of an unfortunate accident, all parties are held liable until proven otherwise."

"The fact that the design engineer or his field representative is present at the site, he or she does not take on the responsibility of execution but is there as an observer."

"This is the most important part of the construction process—depending on the complexity and size of the project. A qualified inspector should be capable of handling routine checking and interpretation of plans—the SDE should be there when he is needed—and at unannounced times."

"In our firm we do not instruct a contractor, "how to build". We try to interpret plans and specifications for proper placement of structural items and good workmanship. Poorly prepared structural plans, sloppy workmanship and a contractor who looks for loopholes to short-circuit the job can cause immeasurable problems and class action suits."

b. Engineers

"We normally provide that our geotechnical (foundations) engineers review in the field the condition of critical portions of structure foundations during construction. This question is answered with regard to our experience in heavy construction projects only."

"The project structural engineer should have access to the site (and be compensated for his time) according to this independent judgement. Construction processes, shop fabrication techniques, and erection techniques affect the performance of design. We normally require resident engineering surveillance of our designs on major projects but are *sometimes* not permitted to participate by our "client."

"Any presence on a construction site enhances the chance for inability claims. We, however, hold to the older premise that our value of service directly relates to the extent that service is given. Field presence is essential to complete service. Training with respect to how our field representative conducts himself is necessary and this leads to the development of "qualified specialists." Chief concerns are (1) OSHA, (2) giving of instructions, (3) contract document interpretations, (4) written confirmations, (5) "loose talk", (6) understanding of "authority roles" in the construction process, (7) field "logs", and (8) risk management procedures."

"Structural engineers are usually called to go to the site only when problems ocur."

"Normally on call whenever the resident engineer would require them. The same as any of the professionals; normally the architect is lead professional."

"He probably will incur additional liability."

"A technically qualified representative of the structural design engineer should be on the site during the construction of the structural frame. Unfortunately, this is not a normal practice. Typically, the structural design engineer only visits the site at infrequent intervals."

"To be fully effective in ensuring structural integrity, the structural engineer needs some authority. Once this is given to him the "lawyers" assume he is responsible for everything and his liability increases

manyfold. It seems the only solution is to require insurance coverage for the structural engineer on each project. The cost of such insurance would be paid for by the owner/developer as a separate item from the design fee."

"We require the structural engineer to inspect only those items which he feels are critical. The regular inspection is by our on-site inspector."

"Due to his unique training, the structural engineer could be held liable for temporary shoring and bridging even though he did not design these facilities."

"Design engineers should have a representative on the site at all ties, i.e., full-time resident inspection. This is a common procedure for heavy construction—bridges, piers, etc.—but not for buildings. This the prime reason structural failures have occurred—in our opinion."

"A structural engineer or his representative who is qualified to check the work should be present. It is not necessary that this engineer be the designer providing he is competent and thoroughly familiar with the design."

"From a practical viewpoint, the structural engineer's liability is probably not significantly effected unless his presence at the site serves to interfere with the contractor's methods and techniques of construction."

"On major projects, the structural design engineer or his professional engineer employee(s) should be on-site at all times during the construction of the structural system, and in the shop at all times during fabrication."

"Generally speaking, we believe the structural engineer should be present during key construction operations, but not necessarily all the time. We subscribe to the approach of a resident observer throughout construction who can call on specialists such as a structural engineer, as required. The engineer should make the determination when such services are required as opposed to "being on call." Most clients tend to attempt to cut costs by eliminating or reducing this important project phase."

"Actions of any resident observer can create exposure to liability. Safety, which should be the responsibility of the contractor, is a prime example. If the resident "steps in" to have a safety problem corrected, the courts may take the position that having assumed part of the responsibility, all safety responsibility 'belongs' to the engineer."

"Project structural engineer should visit the site during the critical phases of construction. Pre-construction meetings should be held for all critical and complex projects. On large projects, a resident engineer is generally on-site."

"By visiting the site regularly, the structural engineer can help to eliminate misinterpretation of the documents or can foresee problems arising from construction techniques being used. However, being on the site he exposes himself to a class action suit for conditions he may not be responsible for."

"For public structures, a representative of the architect and engineer should be on-site during construction of major building elements."

"Anyone on-site may be named in litigation involving accident, injury, losses, etc. The engineer is no exception."

"Full inspection should be required on all projects. Often minor changes are made on site which can affect the safety of the structure or compromise the design. Many foreign countries where it is mandated that a qualified, licensed (special examination), structural inspector (engineer) be retained by the owner (or contracting party) to oversee the erection of all structural elements at the site. This inspector is not from the design engineer's staff. He (or the company) is a separate professional acting on the owner's behalf. He is retained just prior to construction so he may have the time to familiarize himself with the documents and cause changes to be made if deficiencies in the design are discovered."

"If the words 'beyond his control' is defined as being outside his legal responsibility then I see no liabilities other than a nuisance suit—a class action suit. If, however, 'beyond his control' implies other than legal responsibility—moral, ethical, 'professional' (mystique) responsibilities then he may suffer liabilities involving total project safety. This is a legal question which is of great concern to engineers. The presence of a full-time representative sometimes leads to legal exposure from unrelated claims, i.e. enforcement of OSHA regulations, etc."

"I believe the structural design engineers are the only logical persons to inspect construction essentially because they are intimately familiar with design requirements. On larger projects this should be adequate additional staff while on small projects, occasional visits may suffice. I think 'on call' is a poor second choice, since this is usually used to correct problems rather than avoid them."

"It is important that the role of the engineer be carefully spelled out. He should assume no supervisory role since this infringes on the contractor's responsibilities and authority. He should only be required to advise the contractor of the acceptability of the final product and to measure pay quantities. Other than that, he should call to the attention of the contractor's superintendent (without obligation) other deficiencies or unsafe practices."

"Many of our projects do not warrant full-time representation. We are sometimes faced with clients who accept "design only" contracts which limit scope."

"Such precedents are not familiar to us but we have been informed of them."

"Foundation construction should be the responsibility of the project geotechnical engineer working in close concert with the structural engineer. Construction of framing (i.e., above-ground construction) should be closely monitored by the structural engineer. The structural engineer should not necessarily be on the site during construction but he should be represented by quality control engineers and technicians responsible to the owner and design team—not the builders."

"The structural engineer's liability should be limited to the accuracy of his design. By being on-site he may incur additional risk by being held wrongly responsible for the quality of the contractor's work. Accordingly, he must be afforded some protection under the law so that he will not be subject to claims generated by non-complying work. The engineer cannot serve as a policeman or an insurer. The contractor must be responsible for building the structure in accordance with the contract documents regardless of the degree of inspection involved."

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"Should be on-site as often as necessary to assure that foundations and framing is constructed as designed."

"The structural design engineer or his representative should be on-site during critical phases of construction. Critical phases should be defined by the structural design engineers."

"They need not be on-site all of the time. However, they frequently are not on-site at all which is a serious deficiency."

"The potential liability associated with any design professional even visiting the site has become too numerous to list. These range from project safety to liability on contractor designed sharing."

"The design engineer knows best when he should be at the site and he should schedule his visits accordingly. No one wants to pay me $60/hour as a full-time inspector and I'd be bored; of so little use. It takes good judgement to design, and that good judgement should be used on regular site visits. If you wait for a call, it is usually too late."

"It would be costly to have a competent structural engineer on the site during all structural work and would only cause a minor improvement. Most firms would station a traineer or a lower level engineer to save money. The design engineers who know best what is required are not generally good inspectors and may even try to cover their own errors if they become too close with the field personnel."

c. Construction firms

"The project structural design engineer has to be on-site during the construction of the foundations, framing, etc. As to the placement of reinforcing steel and structural steel connections, the engineer should be on-site during those periods. It's not necessary that this site inspection be full-time, however, it should be checked by the resident engineer prior to the pours or before structural framing is covered."

"By being on-site, a structural engineer would not preclude himself from being named in a class action suit. In the case of an injury, a suit is filed against all parties involved with the project including the structural engineer, regardless of him being on-site. Total project safety is the responsibility of the general contractor with sub-contractors being responsible for the safety of their own personnel."

"Only on call; however, they should be represented by a competent inspector during all structural work."

"Should have a qualified engineering representative on project during critical structural construction phase."

"They should make routine inspections of critical items during the foundation and framing work."

"This should be the responsibility of an owner-hired (qualified) agency—built to drawings and contract documents."

"A structural engineer's liability would be 'No more that he would have by designing the structure—I'd suppose. I'm a contractor, not a lawyer.'"

"Site-experienced professional always an advantage. Lack of experienced professional could lead to contruction disaster."

d. Construction managers

"Structural design engineers spend most of their time in the office performing their design duties."

"A qualified construction manager or general contractor will effectively manage these operations during all but the most unusual circumstances."

e. State and building code officials

"On-call—depending on complexity of project."

"On-site during critical periods."

"A project representative versed in construction methods should be present when critical structural-related items are poured, erected, etc. When a question arises then the structural engineer should be contacted for clarification. This process should be a minimum requirement."

"Why should anyone be responsible for liabilities beyond this control?"

"If the project structural design engineer is on-site all the time, it would be abnormal. Usually this is a responsibility sub-contracted by the main contractor. If there is a major project involved, I respectfully submit the project structural design engineer is the individual best qualified to be on-site."

"Unfortunately, being on-site or not being on-site does not dictate the liabilities to be incurred beyond the control of a structural engineer. The 'deep pocket' syndrome surfaces to confirm that anyone can be sued."

"The soils consultant is called to inspect the footing bottoms to assure the State that conditions agree with design information furnished to the architect and/or structural engineer. A/E contracts call for periodic inspections by architects-engineers. Inspections are provided on a judgment basis."

"We feel licensed designers should be more involved in the monitoring of construction. Even to the point where more responsibility is shifted from the governmental sector to the private sector for compliance with construction standards."

"The structural engineer could possibly be held responsible for unsafe construction practices, he might observe and not comment on. The contractor for a project should also be made more responsible for compliance with construction standards. Again the private sector must be made aware that they are the ultimate party responsible for compliance. Now it is a game that the government is the responsible party, when really their function should be one of monitoring. The attitude of the private sector appears to be if they catch me I will comply."

"It depends on the complexity of the project. The designer should inspect installation of work he designs."

"The complexity of the project should determine the number of site reviews to be made by the engineer."

"On larger construction projects, structural engineers are more likely to be on-site with a greater degree of frequency."

"Beyond the specifications of the design, the structural engineer would probably not be liable for a contractor's practices or deviations. Ultimately a court would decide."

"The project engineer/manager should be on-site to assure all construction details of the structure are built as designed and approved. One option of course is to require an official engineering change order be processed through an approval loop prior to an engineer allowing any contruction to deviate from approved design."

"I am an engineer, not an attorney; however, I believe the structural engineer is responsible for his design and certainly any engineering changes he approves. It seems reasonable to me that the engineer would be responsible for any detail he inspects and approves during construction."

"Should be available. Should make regular checks."

"More than if not on-site."

"Contract administration and supervision of construction is a contract responsibility of the design architect and his engineering consultants. They monitor the contractor's activity on both a regular and 'on-call' basis."

"If a structural problem results, the engineer will automatically be involved and cannot escape his responsibilities."

"Design firm representatives should be on-site at critical times and at regularly scheduled times but *not* at all times."

"With a limited state field inspection force, the structural design engineer should be on-site."

"A structural engineer should be on-site during critical phases of structural construction."

"Any liability would be dependent upon specifics of incident."

"Should not be necessary for SE to be on-site during the entire construction. Owner should have an engineer on-site to see that construction is per plans, and recognize problem areas on which the structural engineer should be consulted."

"Legal suits could arise against structural engineers even if they are not on-site."

"Although this is happening less often, the structural design engineer should be present during basic and critical structural construction periods, i.e. concrete pours."

"Under Illinois law, a licensed person on-site during construction has been held responsible for what has happened."

"If the structural engineer cannot be on-site at all times, he must be present during structurally critical periods and on-call all other times."

"This is really a two-part question. It would be desirable to have the structural engineer on-site during the critical parts of each phase. Otherwise, design and fabrication are separate responsibilities but in difficult or critical areas the structural engineer should be on-call."

"This is a legal question in that the structural engineer can not be held responsible for events and actions that are beyond his control."

f. Owners

"Periodic site visits at the beginning of each structural field of work is recommended. Such as steel erection, foundation pours, etc."

"The structural engineer may acquire other duties related to safety if on the job continuously. Thus, the liabilities may be increased."

"In our work, we do have soil specialists of the Department on the site of major foundation components at the time of full excavation to approve the soil conditions. Other than this, structural engineers are on-site only on spot checks."

"Liability of a structural designer would not be increased because of his presence on-site unless he observed something being done contrary to the plans and specifications and did nothing about it. If it is a case of faulty design, he would have the same liability whether he were on the site or not."

"Yes; the project structural design engineer, or his representative, should be at the site at all times during construction of foundations

and erection of structural framing, etc. This is not a "normal" practice."

"Structural design engineer or his representative should visit the site at critical times during footing excavation/preparation; pouring of footings; steel erection; concrete forming and pouring; metal deck installation. This does not require full-time inspection. Proper soil concrete and steel (including connections) should be tested by an independent testing laboratory during construction and base."

"As a general policy, structural engineers should be required to be on the site as a contract requirement where it is determined that critical elements require that expertise for quality control."

"On-site, per se, would not add to potential liability for any design defect. If he observes non-compliance with design, he would have duty to report. If assigned inspections and construction compliance duties, any liability would flow from his performance as non-performance, i.e., within his control. The engineer would always be named in a class action suit, but his on-site presence alone would not increase his liability for design or compliance with design in construction."

"The engineer should be on the site at all times when structurally significant construction is taking place. This does not necessarily mean at all times during construction, however."

"Should incur none so long as his actions do not infringe upon those which are the responsibility of the contractor."

"The structural engineer is normally not on the site all the time. An Architect's Site Representative (Clerk of the Works), and/or an assigned structural representative retained by the Architect, should be on-site at all times. The structural engineer should make regular visits during the construction of foundations and framing, and be on-call for particular problems."

"The liabilities of the architect and his consultant structural engineer do not diminish or increase by the structural engineer being at the site. His presence could obviate problems which would otherwise go undetected and generate suits, or detect design conditions which require immediate review and revision to prevent failures."

"It is important that the design structural engineer visit the project at unannounced intervals during major phases of the construction to check for conformance with design requirements."

"It is not necessary that the structural engineer be on-site all the time as the designer is not always versed in the practical aspects of construction. However, any changes in design should be verified by the structural design engineer."

"If the structural engineer makes no decision changes while at the site, his liability should be no greater than that he incurs as the result of having provided the design."

"Agency assigns resident engineers to be on-site at all times. Designer visits site."

"They will be on my project."

"Engineer is responsible and liable for structural design. His presence is to insure construction meets design requirements."

"Washington Metropolitan Area Transit Authority (WMATA) has engaged a Central Construction Consultant (GCC) to supervise the construction. Resident engineer and inspector are provided by

the GCC for every stage of the construction. Structural engineers are consulted when questions arise."

"Our major bridge projects are staffed with a resident engineer that is a registered civil engineer. The design engineer is available for discusion or consultation at any time."

"Caltrans assumes responsibility for its employee."

"Structural design engineers should be on-site during major structural construction activity. During this period structural engineers at Dallas/Fort Worth Airport are on-site and visit the construction sites daily as the other construction activities occur."

"In the event of a structural failure the structural engineer would be considered liable with all others of the design team whether on the site or off the site."

"Adequate deputized inspectors should be on-site, assuring no unauthorized deviations from original approved designs."

"Operation in this manner would prevent government inflexibility, cronyism, paying off inspectors, and the ever-growing maze of rules and regulations of the time-consuming permit process that is causing unnecessary billions of dollars in interest."

"The field offices have engineering capability. The designer is available if needed, but the plans and specifications should suffice for the contractor. The contractor is required to submit detailed reinforcing shop drawings prior to construction which the construction inspector utilizes to assure proper forming, bar placement, etc."

"The A/E of record is liable for his design and would not be on a Navy construction site unless requested."

"The structural design engineer is generally not on the site. The project is administered by a project engineer (generally a licensed professional engineer). His staff consists of concrete and steel inspectors, who inspect the work being performed based on the shop drawings approved by the structural engineer. Should structural inconsistencies be found at the site which will require deviations or changes to the approved shop drawings, the structural engineer will be called to the site to inspect and analyze the inconsistency and recommend a course of action."

"A structural engineer incurs no liability merely by virtue of his presence on the site. Under Transit Authority contracts, the construction contractor bears the primary liability for any personal injury or property damage. The engineer is liable only to the extent of his own negligence or other misconduct except if he agrees to indemnify the Authority beyond that liability."

"In addition to being on-call, the structural engineer should make frequent visits to the site and inspect the construction to make sure it is constructed as he designed it."

"Large projects—on-site. Small projects—on-call."

"Purdue uses its own construction inspectors for all phases, with design engineers on-call as needed."

"This depends on whether or not his being on-site was by contract agreement or by invitation to examine or discuss a particular problem. His liability should be tied to a written document which describes the scope of his responsibilities during construction."

g. Developers

"Structural engineers should inspect their work to see if it is per plans or if there could be discrepancies in the plans and as built in field. If he does not inspect, there should be an inspection service doing his inspection."

"Liabilities are hard to avoid—but he possibly could bring some safety and work methods into proper alignment."

h. Banks and financial institutions

"In-house project manager and/or project architect monitor the project for compliance to plans and specifications. Structural engineer is on-site as needed."

"Job site visits should vary with complexity of structure. Verification of proper placement of re-bar and placement of concrete is important and worthy of observation by the structural engineer and/or the architect."

"I am not familiar with his potential liabilities."

"The structural engineer should have a representative on-site during all critical points of the project. Thereafter, period field inspections should only be required."

"The engineer would have the same liabilities whehter on-site or not; it's still his design. By being on-site he can insure that his design is properly executed."

"They should inspect certain stages as a matter of course."

i. Insurance companies

"We are not of the opinion that structural design engineers should be on the site at all times. We feel that a clerk of the work should be employed on large projects as a representative with the architect. The clerk of the work should be sufficiently astute to see that the foundations are inspected by a qualified geologist and that field connections on structural steel are properly torqued in the case of bolted connections and that welded connections are made by a properly licensed welder. The structural engineer should be available at any time that the clerk of the work feels his expertise are desirable on the job site."

"We cannot imagine that the structural engineer would incur any liabilities by virtue of visiting the job site other than the liabilities for the structural design which he has prepared."

"Frequently they are not called for critical inspections and hence the condition goes without inspection."

"On major projects structural engineer on-site. On other projects the structural engineer is fully aware of schedule (concrete pours, etc.) and inspects such events. Oftentimes additional re-bars are added. We also have testing firms on all projects and on-site Aetna construction supervision."

"Don't really know. Structural engineer present at site is standard operating procedure on our projects."

"During foundation work and at certain periods during steel work and or structural tests, etc."

"Structural engineers should make periodic site inspections during these periods. Visits normally depend upon the contract language."

"All engineers and architects should make inspections as predeter-

mined key points where work in place is open to inspection and corrective actions can still be taken."

"We feel he should inspect the structural system of the building on a prescribed schedule that checks on critical structural system."

"He might not be aware of some deviations from the structural design that the contractor could have taken when he was not in a position to observe such deviation."

"Totally depends on scope, sophistication and type of structural system—wood vs. concrete—high vs. one-story—long or short spans. Structural inspection is a must, however, this should be interpreted with other testing such as soils, concrete. Favor utilizing independent, unbiased testing company contracted to owner."

"The design engineers, typically, should be (by contractual provision) on-site to inspect each phase of construction for which they are responsible to insure plans and specifications are adhered to. Additionally, they must be available for consultation at the owner's request."

"This is an area that is normally defined by contract and subject to legal definition and interpretation."

"Either the project structural design engineer or a qualified independent inspection and testing firm should be on-site during the construction of foundations and framing. Structural engineers normally visit the site periodically during this phase of construction, which leaves too much to chance."

"Structural engineers might, in fact, lessen their liability by being on-site. Proper documentation of any deviations from plans and specifications would certainly serve the interest of structural engineers in the event of structural failures."

"This assumes that provisions have been made for a construction supervisor, clerk of works or other means of insuring that construction is in accordance with plans and specifications."

"This is usually done by an independent testing firm on-site. The structural engineer approves shop drawings and makes periodic inspections."

"None, that he doesn't already have."

"Structural engineer should be on-site periodically, at engineer's discretion, to assure building constructed in accordance with approved plans. No sense to have engineer on-site all the time."

"The same liabilities all other professional team members (architect, builder, etc.) incur by being on-site."

3. OVERALL PROJECT ACCOUNTABILITY

Who should have the overall accountability for the structural integrity of a large construction project; the owner, developer, architect, structural engineer, builder, or building code official?

a. Architects

"The overall accountability for any structure should, in the first instance, be with the owner. After all he is the initiator of the project and as such, has a responsibility and obligation to provide for the safety and welfare of the occupants and the public at large. He can fulfill that responsibility through the hiring of capable and competent designers and through his willingness to pay a reasonable fee for

the services he expects to get or he can create a marginal situation by selecting those services on the basis of the bottom dollar he can get. The same general logic follows through the building of the project with the builder. There is a saying that you get what you are willing to pay for and we believe this to be true. Nobody is in business or can remain in business without making a profit and it should be well recognized that there are no free lunches and you don't get something for nothing. Somebody has to pay. If, in the final analysis, the owner has acted responsibly in all cases, then his liability should pass to one or more of the other participants with whom he has contracted should a failure occur. Fundamentally, the structural engineer is responsible for the structural integrity of the project within the standards prescribed by code and good engineering practices, if it has been constructed in accordance with his design. If it has not been constructed in accordance with his design, then the builder should be held accountable."

"The architects and engineers of all disciplines have prepared documents that should clearly define the project. These should be coordinated and checked and set the complete requirements and "picture" of the project. However, the contractor (builder) is responsible, and under contract, to build it in accordance with those documents. The architects/engineers are responsible for correct design . . . the builder for correctly constructing the design."

"Many considerations and variables impact on the design of a large project similar to proper orchestration of a musical composition. During the design phase, all of the variables get evaluated and coordinated by the experienced professional in the preparation of design documents and specifications. During the construction phase, accountability and responsibility of execution reverts to the contractor/builder."

"Some inspection departments are undermanned and consequently the contractor can bet by the A/E unless he is hired by the owner to have a qualified observer to oversee his work. The owner has the least input unless he is the prime contractor—it is then necessary for the architect, structural engineer, builder and owner plus the BCO be made aware of unusual structural details, design, unorthodox connections, and fully understand the importance of proper execution."

b. Engineers

"Obviously this question is subject to interpretation. The ultimate responsibility lies with the developer. The distribution of his accountability, however, is totally dependent on how professional he is in his business conduct and contracting procedures. The breakdown occurs when *any* member of the total team of public and private participants acts in an unprofessional manner by instructing or carrying out an unprofessional act. In a properly enacted project, accountability for errors in judgment can be easily placed."

"All of these people share accountability. The degree of accountability will depend on the involvement."

"If the project is a building, the architect is the lead professional. The code official should ensure that the construction meets all requirements of current codes. The structural engineer is responsible for his

area unless the architect has made changes to the building and forgot the possible structural effect."

"The structural engineer is the logical person to have overall accountability for the structural integrity. If not the structural designer, then a registered structural engineer competent and experienced in the type of structure being built should be employed, preferably by the owner/developer."

"If the structural engineer is given the responsibility for structural design and control over shop and/or erection drawing and is permitted on-site inspection, then he should assume accountability. If the owner splits the responsibility, then strict accountability cannot be assigned."

"The structural engineer is responsible for his design. Construction procedures and changes should also be checked by the structural engineer."

"Although the engineer should have overall accountability for structural integrity, this should be limited to design integrity. The contractor or builder must retain accountability for structural integrity that results from construction procedures, sequences, proper materials, etc. The ACEC (American Consulting Engineers Council, 1015 15th Street, N.W., Washington, D.C. 20005) standard documents spell out the separation of responsibilities very clearly and properly."

"Though a structural engineer is responsible for overall structural integrity of a large project so far as the design is concerned, it is the responsibility of all parties involved for the successful construction of the project. The builder will have overall accountability for construction methods and techniques employed."

"Shared responsibility—engineer for design safety—builder for construction as designed."

"The architect does have (accountability). He usually delegates that responsibility or accountability to a consulting structural engineer. Architect, engineer and builder all have roles which can influence the result, therefore they share accountability."

"In the type of project with which we are involved, the client is usually a State Department of Transportation or connected directly therewith. Since they have engineering staffs of their own who have developed standards and have made many other engineering decisions, it seems that they should share this accountability with the design engineer and the engineer providing construction."

"We as structural engineers of small as well as vast projects (particularly overseas work where proximity is remote) value the interaction of and sharing of responsibility by *all* parties, most important, (a) owner—writer of service contracts, (b) architect—our client, (d) builder—as executor."

"Except in cases of design error the contractor (builder) must be held accountable. Obviously, if there is an error in design, then the responsible designer is accountable."

"Structural engineer *if* he is a prime professional and if he has resident engineer responsibilities. When the architect is the prime professional, the structural engineer is a consultant to the architect, and the architect is responsible for overall accountability."

"The builder and the structural engineer should work together on large, or small for that matter, construction projects. Therefore they both should have the overall accountability."

"Although the structural engineer should, most on-site inspections are performed by the architect. Typically, the inspecting architect may not have sufficient structural background to be aware of defects."

"No one but the structural engineer has a reasonable grasp of what is right structurally. But he cannot afford the insurance to provide the financial backing nor does his interest carry over the life of the building. The owner should be responsible for his property—totally and absolutely—relying upon the advice of competent professionals and the financial backing of his insurance."

c. Construction firms

"The architect should have overall accountability for the structural integrity of a large construction project. However, the structural engineer is a consultant to the architect and therefore, as a professional consultant, has a liability for the structural design of the building. In the case of structural failure, whoever is found by examination to have failed in his responsibility, should be accountable. If the owner failed to tell the type of equipment that was going to be placed on a floor, the owner/developer could be held accountable. If the architect failed to tell the structural engineer the floor loadings he could be held accountable. If the structural engineer failed to design the floors for the loads intended, he could be held accountable. If the builder failed to provide the materials called for on the plans, he could be accountable. If the structural fabricator or subcontractor failed to properly fabricate the materials he should be held accountable."

"Structural engineer should be accountable. "Building Code Officials cannot have the staff large enough to function for all the projects in their jurisdiction."

"The structural engineer should have the total responsibility—inspection and anything else that he has to do to be responsible. Building code officials should check plans and be responsible for that and then stay home."

d. Construction managers

"Actually a team effort among architect, engineer, and builder, but engineer has specific responsibility to create structural integrity. Builder is obligated to construct in compliance with plans."

"Architect, structural engineer and contractor have to share in efforts to provide structural integrity for a large construction project."

e. State and building code officials

"Our contracts, normally building construction, and are with the architect. Structural engineers are normally consultants to the architect."

"Owner—responsible for proper usage; developer—responsible for proper scope and initial input; architect—for proper coordination and overall design; structural engineer—assist architect during design and provide proper structural design calculations; builder—perform proper construction methods and follow specifications with proper questions; BCO—check to see if code has been followed."

"Since the owner is not expected to have design or construction expertise, the accountability for structural integrity rests mainly with the architect, his structural engineer and the builder."

"'Joint responsibility', architect, structural engineer, and builder."

"The building official should only monitor the construction and once the violations are pointed out the others must assume the accountability for compliance."

"The architect and his structural engineer consultant have design responsibility—the owner and contractor also have responsibility as the project is constructed and occupied."

"The architect (the designer) would have overall accountability for a structure. The structural engineer, the builder, and the building official have lesser, but nevertheless important roles in making sure the construction follows the design."

"I believe the project manager (builder) and the structural engineer and architect must share the total responsibility for structural integrity. The building official is accountable to assure the structure is built like the design; however, the uniform building code states that he cannot be sued as an individual. I believe this implies some softness in his liability. I believe history teaches us that in most major catastrophic structural failures, either a change was made during construction to the design without benefit of the structural engineer's review and approval or a designer made an error by failing to include all loading in his calculations, thus resulting in a design deficiency."

"Individual or firm responsible as designated. May vary from project to project."

"The architect, assuming he has the design contract with the owner, has the overall responsibility."

"This is a joint responsibility which should be shared by all."

"Overall accountability should not lie with one individual or group, unless it was a design build project."

"Each of the individuals indicated at the left must share in the accountability for the structural integrity."

"All three must work as a team. Structural engineer would have the final, overall responsibility."

"Historically, the architect has overall responsibility for a project as the contract is between the architect and the owner. The supporting disciplines are employed by the architect for the design and development phase. If the contract between the architect and owner is for design and development only, then the builder is responsible to see that the construction is in accordance with the architect's approved plans."

f. Owners

"The West Virginia Department of Highways accepts full responsibility for a project after the project construction is accepted. Interim conditions are generally the responsibility of the contractor. If work being done by the contractor is in accordance with our specifications and plans then the responsibility is the Department's. Although erection procedures are reviewed by the Department, this does not relieve the contractor of responsibility for that portion of the work."

"The structural engineer should be held accountable. The detailer of shop drawings and the steel fabricator and erector should also be held accountable."

"The owner hires an architect who in turn retains a structural engineer—therefore the architect is contractually responsible for the structural engineer's work. The builder builds buildings. If he doesn't comply with drawings and specifications then he is accountable. Building inspectors approve drawings and grant building permits; but they take no responsibility and in fact do no review of structural elements."

"No one person should or could be accountable for the structural integrity of a large construction project. Development of any large project entails the working together of all parties to assure that a safe end product is the final result."

"However, this presumes that the structural engineer has prepared a complete set of documents for the project (not an abbreviated set as some developers will extract) and that the structural engineer will conduct inspections during construction. No state law requires on-site inspection during construction as a statutory part of the requirement for the architect's or engineer's professional services! Those services are legally fulfilled with completion of the contract documents."

"The developer is generally setting the policies for the development of the project. He should have accountability for the overall project. The architect, structural engineer, and builder should be responsible for the work they perform."

"To some degree, all of those named should have accountability for those things which were under their control. However, primary accountability should rest with the structural engineer for the design and the builder for the proper execution of the design."

"The structural engineer should have the overall accountability for structural integrity of the design of a project provided the structure is built by the contractor in accordance with the plans and specifications. However, all the parties mentioned may also have to share the responsibility or role of each party was."

"We deal with public works projects only (highways and bridges) and we consider the owners as having overall responsibility. If a consultant did the design work then he should share in the responsibility."

"It is difficult to make one individual totally accountable for structural integrity, but the primary responsibility should lie with the structural engineer and the builder. Materials suppliers, not on your list, should be responsible for their products (product liability)."

"Any entity having authority to approve or alter the design."

"This questionnaire is obviously aimed at and is in and of itself more government intervention. This is the exact opposite direction in which you should be heading."

"The engineer is responsible for producing a professional product."

"Because of the differing nature of their functions, it is not possible to assign overall accountability to any one participant in the construction project. Each participant must be accountable within the scope of his own area of responsibility. But, none can be considered accountable for matters outside that area, since he cannot realistically control the actions of the other participants."

"The architectural/engineering firm has overall design responsibility with the structural engineer having departmental responsibility. The contractor/developer/builder is responsible for construction meeting the engineer's drawings/specifications."

g. Developers

"Prime persons responsible are the architect and structural engineer—then the builder also has to erect or build per plans and specs and then the inspector who evaluates the construction and/or inspects. If the developer and owner deviate from plans and specs they could be responsible."

h. Banks and financial institutions

"If only one answer is sought, the builder should be accountable."

"All parties contribute as a check and balance."

"The builder must be responsible for carrying out the design per plans and specifications."

i. Insurance companies

"The architect should have the responsibility for employing, with the concurrence of the owner, the structural engineer as well as other principal engineering disciplines, and the architect should have the primary overall accountability for the facility. Needless to say, he is backed up by the structural engineer. An assumption should be made at this point that the engineer has prepared the building plans to the applicable building code and that the builder has executed his work in accordance with the architect's plans and specifications."

"The architect in turn must delegate the structural work to the structural engineer since the architect is generally not knowledgeable on structural work."

"The architect has overall accountability for work of all consultants reporting to him. Our fee paid to the architect includes fees to structural, MEP and civil engineers. Owner also accepts a significant amount of accountability. Owner/architect/construction manager work very closely and mutually critique each other's work."

"A building code official can not be by virtue of physical properties, time and budget be held solely responsible for structural integrity."

"The party most qualified to determine the structural integrity of a large construction project is qualified structural engineer, but I could not state unequivocally that he should have overall accountability. He should, however, be accountable for 'approving', not just 'reviewing', all shop drawings that affect the structural integrity of the structure."

"Could be architect if he contracted with structural engineer."

"Owner and developer usually are not technically knowledgeable. Architect, builder and building code official should question anything they see that might raise a doubt and should be responsible for doing what the structural engineer says to do but the structural engineer has ultimate responsibility if the design is installed in accordance with his instruction."

"All except the owner."

4. IMPACT OF COST CUTTING ON DESIGN

How should architects be selected for a project?
How should engineers be selected?

a. Architects

"For the past ten to fifteen years, Architects and Engineers involved in the building industry have been faced with an environment of

performing more work for less fee on an accelerated basis. We are the first to admit that this has not all been bad in that it has forced us to seek new ways and methods of becoming more efficient and more effective in the production of our services. This has compensated to some degree for the reduced fees, but not totally. As with everything, there is a threshold where striving for even greater efficiencies results in loss of effectiveness and we are of the opinion that the design profession as a whole is approaching or in fact may have passed this threshold. The fundamental commodity of the design profession is the selling of time. If the fees generated do not support the time to adequately perform and the expense inherent with liability exposures, the ultimate result can only be the demise of the oldest profession known to mankind, discounting of course, prostitution. The architectural profession is the lowest paid of all of the professions and yet, in our view, has the greatest exposure to liability. We are without question drastically underpaid for our services and the risk we take. From the standpoint of return on investment, there is no way to justify the educational requirements as they exist today for an architectural license when compared with other professions."

"The architect and the engineer negotiate their fee for the work and should be experienced enough to negotiate a proper fee. Regardless of the fee, we are professionally bound to produce a satisfactory design. The percentage of fee varies with the size and complexity of the prospect and cannot be classified as the same over all."

"Percentage fee received by professionals is not in keeping with the responsibilities involved; however, this is no justification for professionals of high integrity not to deliver designs that are not thoroughly verified."

"Compensation for the services of a professional, varies with the complexity and size of a project. To give a percentage would be misleading; however, an accepted figure for an average project amounts to about 6 percent."

"The larger the project the greater the difference in the A/E fees—depending on the market and the work loads (especially large offices doing the larger work) results in fee cutting—result—subquality plans—across the board. The percent of A/E fees based on construction cost should be derived from in-house cost studies based on track record, especially if M.E.S. is farmed out. We cannot work below 7 percent for projects 1×10 6 (new work)."

b. Engineers

"This question highlights our Company position on the need for separate architectural and engineering contracts. What price should be put on the extremes of the creative role of architecture? Increased creativity generally means higher complexity and architectural costs. This also means higher design cost. Both the architect and the engineer can be competing for fixed dollars (or, if OMB had its way, low bid dollars), creating a Catch 22 situation for the developer and the project. This can have a devastating effect on a project."

"Generally speaking the answer is no. Also, 7–14% of construction should be allocated for design depending on the job."

"We cannot answer for architects or other engineers, but the current practice of 'shopping' for prices or actually bidding is a sure way to

reduce the amount of time and expertise spent on review and verification of design. The use of a percent of construction cost as a measure of design fee is an accurate guide. Fees should be set by negotiation after selection."

"In most cases the fee is adequate to prevent structural failures but not to provide the most economical design."

"This is the most important area for improvement. Give the professional the time and money to do the job right."

"The structural engineer is responsible for his design. Construction procedures and changes should also be checked by a structural engineer."

"Fees have had a reduction trend over recent years when addressed from a percentage of construction cost viewpoint. The six percent statutory limitation on Federal projects is no longer realistic, except for massive projects and can result in inadequate funding to accomplish complete engineering and the investigation of all alternatives that could provide economics of construction. Projects are becoming more complicated and there is less recognition that this increases cost of producing designs. Developing trends toward bidding for professional services, now being fostered at the Federal level in opposition to the Brooks Act, are producing the same effect."

"In a majority of the cases, the consultants' fees are not adequate produce complete and well coordinated contract documents. However, this is generally not true for 'cost-plus' contracts."

"Field is highly competitive. Architects and engineers are driven to cut corners, streamline production, move jobs out, etc. They don't consciously cut services but they may be forced by economies to produce the documents rather than spend time in unhurried and thoughtful planning and checking. No fee should be based on percentage of construction costs, but on value to be received through effort earned. Percentage of construction cost is a conflict of interest; not related to effort, quality, good design, safety, etc. Selection should be made first on the basis of ability; second on the cost of services."

"In most cases, clients expect perfect plans down to the smallest detail. Neither time nor money is adequate for this, especially when last minute changes are required. Essential features should be designed and checked thoroughly to assure, without question, the structural adequacy and safe operation. Percentage of construction cost is at best a guide dependent on complexity, range of construction cost, services to be included, etc."

"Generally percentage of construction is used for new construction on a sliding scale depending on size and complexity of project. Some design teams are well paid but regardless of the architect's fee their engineers are often hired when hotly competing with each other."

"None of the design team receive a fee that is proportional to amount of risk they incur. Actual fee should be based on the size of the project. For small projects (less than $1,000,0000), a design fee of 10 percent—12 percent is reasonable. In no case should the design fee be less than 7 percent. Generally, the engineering disciplines, i.e., structural, geotechnical, mechanical, receive a disproportionately small portion of the total fee as compared to the architectural fee percentage."

"Percent of construction cost depends on size and complexity of project and the amount of field work provided."

"Engineering cost as percentage of the construction cost varies with size and type of the project. Engineering societies have established some guidelines. (American Society of Civil Engineers Manual No. 45). Engineering cost will also depend on how much the owner wants to spend on the detailed drawings and how much he wants to spend in the field (at the job site)."

"Typically, the fees have been adequate. However, there has been an increasing trend toward the bidding of professional services, particularly by governmental agencies. Although this saves on design fees, it most likely increases the overall cost since there is no incentive to refine designs or be innovative. A fee based on percent of construction cost is not reliable since projects may vary in complexity."

"The architect typically keeps at least 25 percent of the fee he receives for the structure. We, as structural engineers, find it difficult to produce reasonable structural services for ordinary buildings at 5 or 6 percent, which means that our client architect would have to receive 6½ to 8 percent. Unique structures cost more. I understand that some structural firms work at 3 and 4 percent which is simply not enough to be thorough."

c. Construction firms

"Thoroughly verified design is something that is very rarely done on any building project. The reason is, of course, the cost of doing it and for the majority of the projects, because of similar buildings having been designed by architects and engineers in the past, the necessity for a thoroughly verified design is not warranted. I feel that the percentage of construction costs allocated to design is unanswerable because it is extremely dependent upon the nature of the project and its location meaning hurricane or earthquake related areas."

Architects "are paid enough now but some aren't really doing a good job."

"If they aren't going to do this (meaning verify design), they shouldn't be in business."

"Regarding a high enough fee for architects and engineers, "I think it is their fault that they don't—they are becoming lazy and incompetent."

"The architects and engineers establish their fee and control it themselves."

d. Construction managers

"Varies greatly with complexity and duration of project."

"Answers to these questions have to be qualified. The type of structure, size of the structure and the experience of the professional people all effect the fee requirements. There is always a tension between owners or clients and architects to get quality design for the least amount of fee."

e. State and building code officials

"Since fee should have no relationship to the adequacy of design, this question is not being answered."

"If design professionals are not involved in a project the cost of compliance is passed on to other taxpayers through the work done by the building department. The owner should be responsible for these costs, not the taxpayers."

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"Percent of construction cost will vary depending on complexity of work; 6 percent for open warehouse; 10 percent for hospital; 15–20 percent residential."

"Fee should not be based on a 'pure' percentage of construction. Fee should be on a negotiated basis with a lump sum fee and fee would be based on complexity of each project."

"Money does buy quality."

"Since both architects and engineers are members of their own professional organizations, free to establish their own fees, I must believe the fees are adequate; otherwise, either or both groups would increase their fees to that which they would set as adequate."

"Generally fee is inadequate. Varies with size and complexity of project. Schedules as developed by professional societies are pretty good."

"The 'design fee' including contract administration will range from 6 to 8 percent on most State projects. Seventy-five percent of that fee is paid during design, 5 percent during bidding and 20 percent during construction."

"Yes and no; dependent upon size, type, fee schedule, etc."

"City personnel do not become involved in private fees or percentages of costs."

"This would depend on the design. Basing the design fee solely on estimated construction cost, which at the time design begins is very obscure itself, is a reason there are often difficulties between Owner, Developer, Engineer and Architect."

"Fee schedule on sliding scale based on complexity of project."

"The fees should reflect the complexity of the proposed design and should be adjusted on an individual basis around a standard set of fees such as is published by the American Institute of Architects. It is difficult to place a dollar value on a safe design and the marketplace tends to adjust to value received for value paid for."

f. Owners

"Veterans Administration's design from previous experience have been sufficient. The size and complexity of the project are the primary parameters."

"West Virginia Department of Highways negotiates professional services and we feel adequate compensation is received."

"In Government work the 6 percent fee limitation does not permit a thoroughly verified design. Cannot speak to the structural engineer fee questions since the GSA contracts only with the architect for total building design."

"Fee depends on size and complexity of project."

"A fixed percentage of construction cost is not a proper method for determination of design fees. Fees should be based on an assessment of the effort required to provide a design that will assure a certain degree of reliability and safety if constructed as designed. For complex high-risk structures, more time should be spent on design than simple routine low-risk structures, where failure will not result in loss of life."

"Varies with type of building. The normally acceptable range is 6 percent to 10 percent (non-complex repetitive designs may be

less . . . very complex technical designs and involved renovations may be more). This range should result in a 10 percent to 20 percent profit margin for each project if the appropriate fee is applied. In all instances, the design professional must be able to collect for any 'additional services' required by the owner or by the nature of the work."

"The problem in site inspection by the structural engineer is usually his fee. Most structural engineers, as consultants to Architects, receive a fee that is usually consumed in his drawings, specifications, and approval of Shop Drawings, and leaves site inspection to the Architect's Site Rep. His personal attention at the site is usually limited. Percentage fee of construction costs depends upon the size and type of facility."

"Depends upon negotiations on each project. Architectural fees, which include the fees of sub-consultants such as structural, mechanical, and electrical engineers, landscape architects, sanitary engineers, soils engineers, etc., run in the range from 6 percent (for large, uncomplicated projects) to 15 percent (for small, complex alterations) of construction costs. Structural engineers' fees on building projects run in the range from 1 percent to 2.5 percent of construction costs. On bridge projects, where the structural engineer is the prime professional, fees run in the range from 3 percent to 7 percent."

"a. We are unable to give a yes or no answer as to the adequacy of the fee. The fee as a percent of construction costs would depend on the complexity and innovation of the design. b. The percent of construction cost is not necessarily a good measure of the fee and should be used as a guide line only."

"Percent dependent on type of complexity of structure for hospitals."

"All design contracts are negotiated between the designer and the Authority. The fee is based on the effort of the designer in producing a set of contract documents for the project. It is not based on percent of the construction costs."

"Since we design in-house, I have little experience with fees. I suspect that fees are shaved by both architects and structural engineers to make their services more competitive."

"For design and on-site inspection services. Often costs are not prorated to provide funds sufficient to allow for proper inspection and observation of work under construction."

"Licensed professionals should not accept a fee which does not allow thorough design."

"The Transit Authority's Engineering team includes: (a) Materials Inspection Division; (b) Architects; (c) Structural Engineers; (d) Signals and Communications, Track, Electrical/Mechanical, Heating and Ventilation and Plumbing Engineers; (e) Tech. Specification Writers; (f) Contract Administration and Technical Inspection. Approximately 10–15 percent of the construction cost is allocated to the total engineering teams effort. Approximately 4–6 percent of the construction cost is allocated to the Architectural and Structural Design, with higher figures required for reconstruction projects and complexity considerations."

"Design cost should not be a percent of construction costs, but rather should be that cost required to produce a safe structure."

"Fee has little to do with the quality and thoroughness of design services."

g. Banks and financial institutions

"Nine percent of costs allowable to design varies with size and type of project. Could be as low as 2 percent or as high as 20 percent."

"This answer assumes a 'standard fee' approach as may be defined in AIA Owner/Architect Agreements. Percentage of construction cost may not be the best way to determine fees, again due to the complexity of the project."

"Time tends to be a more essential factor than fee. Percent depends on project size."

"Percentage depends on project."

"If standard AIA fee structures are utilized, then fees are adequate. Unfortunately, many developers and owners do not pay these fees and will not pay for construction administration; and, thus, the architect and engineer cannot monitor the construction process, check shop drawings, etc."

h. Insurance companies

"Architectural fees are normally based on a percentage of the construction cost and projects which we have been involved in, the architect in turn is responsible for negotiating with and paying the structural engineer. Thse professionals are in a unique position. As the cost of labor and materials increase so does the dollar and cent amount of their fees. We feel that payment on a percentage basis is the most desirable unless you anticipate numerous changes during the process of designing and developing final working drawings. In such cases it might be more desirable to prepare plans and specifications using a direct cost arrangement with the architect."

"Our fee is negotiated with architect and includes the services of all engineers. Architectural fees generally range between 4–6 percent. We don't know the portion of this that is paid to the structural engineer."

"Need for flexibility—negotiated fee on complex projects—graduated fee on multi-million dollar projects."

"Can't generalize but most structural engineers operate under some cost pressure."

"The architect should negotiate a satisfactory fee to do the design properly. The same practice should be with architects. Five or six percent depending upon the size of the project."

"Architects and engineers set their own fee structures with the blessing of the American Institute of Architects and other professional associations. There appears to be little difference in fee structures among firms in a given geographical location, and there appears to be little room for negotiation. The fee structure varies inversely as a percentage of construction costs."

"This is normally on a sliding scale basis, and design fees will vary with size and complexity of job."

"This question is not capable of being specifically answered but whether fees are adequate or not is up to the various disciplines and acceptance of job should imply a thorough job."

"Architects/Engineers are underpaid relative to the risks undertaken."

5. IMPACT OF COST ON CONSTRUCTION

What impact, if any, does the rising cost of materials, labor and borrowed money have on structural failures?

a. Architects

"We believe the economic climate has a substantial relationship to structural failures. Simply put, the building industry, comprised of Owner, Designers, and Builders, is running at a frantic pace to stay alive. Owners have over-reacted to buzz words like value engineering and cost-effective evaluation to reduce quality and quality of materials to the lower limit of acceptability. Couple this with a next-to-impossible construction schedule with big liquidated damages and you have the potential for error and sloppy workmanship which could well exceed the margin for error left in the design."

"Owners desire to cut every red cent out of project because high interest often will pare away at structural adequacy to save money."

"When in a corner, for whatever reasons, developers and/or contractors may look for the 'easy' way out."

"However, this impact should not relieve A/E. If owner or developer wants to cut corners to save money, A/E must remain firm on matters affecing safety and must go on record if opposes cut-backs."

"A structural engineer must provide a safety designed structure, and these items should not enter into whether the structure is safe, or not. There is always pressure of time and budget . . . but the safety of the structure should never be allowed to be controlled by such. A structural engineer must protect himself from these."

"Considering the integrity of all parties involved, the rising costs, labor and borrowed money should be no reason for failures. All of the above factors are recognized at the start of a project in preparing estimates and establishing schedules. If the estimates show costs beyond budget, invariably the projects get deferred or other approaches are studied."

"The scarcity of good projects creates intense competition among all size firms. The competent, ethical A/E will turn work away rather than turn out shoddy unprofessional structural design. The end effect is usually that the competent firms weather the storm, but a few of the incompetent firms survive—these cause problems. Some clients are not willing to sacrifice for good work when time is short and money is borrowed."

b. Engineers

"I think there can logically be cases where cost and schedule constraints lead directly to failures. This is possible if unprofessional conduct (business, technical or judgmental) exists. We live in a period of unprecedented change; in technology, client needs, financial, economic, and schedule requirements. With its problems, this is probably one of the three most exciting periods in the history of the modern world. Change as described herein means that methods of the profession must change. This is the obligation of the profession; to improve our methods to meet the challenge of change while maintaining our standards."

"Pressure such as rising costs will encourage the cutting of corners. If corners are cut improperly, failures can result."

"We are daily faced with making vital structural decisions (review of shop drawings, inspection of reinforcing bar placement, review of contractors' construction procedures) on a "crash" basis. Often fabrication of the structural element has begun or even been completed before our review is done. This is done despite the fact that many times the job is delayed while "unapproved" details are corrected."

"Due to these factors, the structural engineer may reduce his normal design safety factor in order to bring the project within budget. The builder/contractor may require modification to reduce costs and the structural engineer may not be consulted or does not have the adequate time to make a thorough investigation since the owner may only be interested in dollars saved."

"Obviously, after money is budgeted for a project, it is important to complete it as fast as possible to avoid escalating costs. This need not mean poor quality; however, it must be controlled by competent people."

"It could be argued that inflationary trends encourage contractors or engineers to cut corners which might affect the structure's integrity. However, the normal experience is not to cut corners but to seek relief through the claims process in order to recover increased cost."

"If a fair and equitable fee is matched with the proper scope of work, none of these should result. A low bid approach can be a significant factor in all of these, since there is no guarantee of competence in the required field and no guarantee that sufficient fee results to accomplish proper design."

"Though a direct relationship between cost and structural failure cannot be established, it could contribute to indirect causes by squeezing the construction schedules or substituting inferior details, fabrication and materials."

"Requests for substitution of materials may be more frequent, but rising costs are generally covered in builder's bids. Structure 25 percent total cost."

"We believe a tremendous impact. Anything to reduce time and cost is considered. While management controls can help prevent the impact of time, awarding work cheap will always cause problems."

"In the field of highways and bridges where some overall control is exercised by the State Department of Transportation and by FHWA, and where safety of the traveling public is at stake, I certainly hope there is no increase in catastrophic failures. On the other hand, where roadway widths may be compromised, and quality may be sacrificed to some extent, failure of components may result, usually only adding to maintenance cost."

"Always a factor."

"I expect that the cost of construction has a minimal effect on the frequency of failures."

"Should have none since designer and builder have responsibility to provide a safe structure."

"Rising costs, particularly in privately financed construction, have required that factors of safety and costs be kept to a minimum. However, where competent designers have been used, this does not represent a safety hazard."

"Those who are making selections will do so in the same manner and will apply the same pressures for economy and scheduling. It was true in the 50's and 60's just as it is today. It is the engineer who must insist on adequate compensation and must take the authority on himself to follow through with his design adequately."

c. Construction firms

"I feel the rising cost of materials, labor and borrowed money has had a significant impact on structural failures. In the extremely competitive situation contractors and architects find themselves today, and because for the most part the structure is cosmetically hidden, the structural integrity is being pushed to the maximum. From personal experiences, I know that architects and engineers used to design structures and select one size larger than actually required by actual calculations by the use of computers today. All the facts are introduced to the structural calculation leaving very little room for any contingencies which may occur. This is done in order to minimize the overall cost of the structure. This elimination of the contingencies for bad workmanship or extra stressing by the owner's requirements can result in an actual failure."

"It better not be a dollar and cents decision to undersign a structure."

d. Construction managers

"May influence owners to accept less than adequate design and construction."

"Faulty materials, omissions and errors of professional people and poor fabrication are the most common causes of structural failures."

e. State and building code officials

"In troubled times, the unfortunate thing is that many times safety is ignored to save money. We are frequently accused of raising costs when requiring compliance with minimum safety standards."

"Cheaper materials will be used where possible. Less experienced, less qualified labor will do less of a quality job. These could have an impact on the structural performance of a building."

"Minimal, however, in an effort to hold costs down many items are minimized."

"Adequate plan checking and inspection are always essential."

"Redundancy has largely been engineered out of most modern systems. Installation has become far more critical as a result."

"This is unknown, but there could be conditions that have direct bearing on material cost."

"Design adequacy and safety is a function of the applicable codes and not on the available funds."

f. Owners

"None from Veterans' Administration project standpoint."

"In our work, there is no compromise on structural adequacy in design due to a financial situation."

"The urgency to meet schedules to combat inflation results in the same number of workers doing the job in less time with a consequent greater chance for errors and a loss of quality."

"The potential for mistakes in the document preparation process increases exponentially as the time allowed for preparation is decreased. The process of checking the drawings (several times is not unusual) is often the first to be eliminated in a tightly compressed document preparation schedule."

"Cost may compete with safety in cases of financial squeeze."

"The developer wants to minimize his investment and squeeze the schedules, thereby creating conditions where in some item may be overlooked."

"It is difficult to say to what extent this might occur, but the possibility certainly exists that a contractor faced with rising costs which cannot be recovered under his contract, might be inclined to reduce his quality control effort."

"We don't believe that the rising cost of materials, labor and borrowed money has any impact on structural failures, if all construction projects follow the procedures specified in the contract documents. We believe that human errors play the major role in structural failures."

"Bad economic conditions probably contribute to skimping on quality in some instances. I don't think this is as likely to occur on public agency projects."

"Due to the high costs of interim financing, many methods have been developed to increase the construction process, i.e., fast-tracking. This involves greater attention to detail with much more manpower and effort required by the design and construction team, sometimes resulting in mistakes. The better the team, the fewer the mistakes. This process can prove very rewarding financially as a method of reducing costs, however, without proper staffing you can quickly eliminate any possible savings that can occur."

"Hopefully, professionalism prevails throughout the design-construction industry and safety is the dominant consideration. All materials have to meet specifications and shop drawing submittal approval."

"From a design point of view you cannot compromise on structural adequacy. There is obviously pressure on contractors to squeeze schedules (cut corners) . . . but a responsible construction administration group should control this . . . without such administration control you could introduce problems."

"Only if quality suffers due to a use of 'cheap' solutions. With a competent designer, this should not be a factor."

g. Developers

"With rising costs, a lot of projects need alternatives to make a project feasible money-wise and sometimes this affects the product. New systems and products are used without enough historical background."

"Reduction of design margins."

h. Banks and financial institutions

"There is a tendency to minimize costs and construction time which, if not controlled, can impact structural integrity."

i. Insurance companies

"We are of the opinion that the increased cost of materials, labor and borrowed money might tend to result in sub-standard structures. When the structure involved is a speculative building shooting for the low

dollar in rental figures, however, we do not see that this should in any way affect the structural integrity of the building being designed."

"This is not a consideration in our projects. Our projects are built to be used by owner, hopefully for 100 years or more. We do not cut corners on structural considerations."

"If a project is suitably located, designed and managed competitively by an owner who is knowledgeable and financed by a lender(s) possessing the skills necessary to properly evaluate an improvement through staff and/or consultants, the impact of inflation on structural failures is indeterminate and possibly insignificant."

"Some designs, which are computer-based, do not allow enough for a factor of safety."

"Should be no impact to save money but some people will do that very thing and rising costs escalate that direction."

6. ADEQUACY OF BUILDING CODES

In general, how up-to-date are building codes and what, if anything, can be done in this area to prevent structural failures?

a. Architects

"In our knowledge, the United States has the most comprehensive and restrictive codes in all the free world. We believe this statement can be borne out statistically by a comparison of lives lost in this country in building structures as compared with other countries. There are those who would say that one life lost is too many and we would agree. However, we also recognize that regardless of technological advancements, as long as humans are involved with human frailties, absolute perfection can never be achieved."

"A good code does not guarantee a good design. Meeting code requirements should never be an 'out' for an A/E."

"Building codes are minimum standards . . . good guides that have been carefully prepared, and are slow to be modified . . . such must be carefully reviewed. However, the engineer still must use his experience and good judgment along with the codes that he follows. There will never be an inclusive code to substitute for this."

"Codes are generally kept up-to-date. When there is a question of inadequacy, the experienced professional uses his best judgement and is not swayed by the minimum."

"Seismic requirements, for specific areas, are covered for the entire country. Since in certain geographic locations wind conditions prevail rather than seismic, the experienced professional makes alternate studies to verify."

"In this portion of Texas, seismic is not too important –O– area. The codes for the most part allows the structural designer considerable leeway. Some empirical formulas must be carefully checked. Whereas the design handbook formulas and selection charts are continually monitored and updated as the technology in ———. Codes in general lack the latest technology. We must remain constantly on the alert to protect life, limb, and property."

b. Engineers

"Codes are inadequate."

"Building codes are enforced by officials who must rely on the professional designers. If design is to code only without using brains, failures can develop."

"Codes can never be "up-to-date." Codes are only changed when conditions require change. Contractors are continually offering materials and construction procedures that are not covered by the code. This requires judgement by an experienced, competent engineer. The building code official generally relies on the judgement of the structural designer when these questions are raised."

"Most engineers design above the codes."

"The problem in general is not the code, but the difficulty in monitoring compliance."

"Performance-type codes, as opposed to specific design codes, should be employed. Performance-type codes provide for latitude in design, require adequate planning and design with consideration of alternatives and demand for true professionalism. Specific design codes may not fit all circumstances and can become a crutch."

"In general, prevailing building codes have proven to be adequate for safe design of projects. However, with emerging new technology, construction techniques, and new products and materials, there is time lag for adoption."

"Building codes are generally adequate. Adaptions for special structures may not exist. Judgement in design is an important element, not just the rules and regulations."

"Building codes generally speak to structures only in superficial terms—live loads, soil bearing capacities, etc. They are related more to the age of heavy timber and masonry bearing walls rather than today's sophisticated technologies. They refer to ASTM, ACI and other industry standards for control."

"Here I refer to such codes as AASHTO, AREA, and State Highway Specifications—I believe are kept reasonably up-to-date. As with any large body responsible for the code, they undoubtedly lag behind available technology."

"Our (Massachusetts) code is the best (to my knowledge) but codes are not always the answer. The state of the engineer's art is the factor and is always ahead of the codes."

"In general, the codes are antiquated, nationwide. There is virtually no way that all codes can be updated fast enough to accommodate the changing state of the art or the changing requirements of modern design."

"The integrity and competence of the structural engineer is the key factor, regardless of the codes."

"Building codes are fairly up-to-date since codes are published every 3 years, 5 years, or 7 years. These do lack information obtained from the research during those years. However, codes are meant to provide guidelines and minimum standards and actual design should be the responsibility of the experienced structural engineer."

"The codes are reasonably up-to-date but must be supplemented by the judgement of the design professional."

"Building codes are of no more value than the officials who "enforce" them. And the bureaucracy that evolves only distracts those who are trying to do a good job from doing so. Competent help is seldom available for building department work and, when found, it atrophies under the political restraints. Structural work can best be checked by an independent structural firm."

c. Construction firms

"I don't feel anything can be done in this area to prevent structural failures."

"Interpretation varies causing confusion and wasted time."

"Don't add any more costs by anything with codes—just enforce the codes that they have by making the engineers and architects responsible."

d. Construction managers

"Codes are appropriate for the state-of-the-art; as new innovations and materials are developed, the codes are brought up-to-date to reflect their use."

e. State and building code officials

"In as much as there are three (3) nationally recognized building code organizations (i.e.: BOCA, ICBC, SBCC), they use a semi-consensus process that sometimes places code changes in the 'behind technology' category."

"The model codes in the U.S. do an excellent job in keeping up with modern technology. There are times, however, that the enforcement persons, through their lack of knowledge, hamper new technology through their interpretation of the model codes. An effort must be made to place code enforcement persons on a professional level. Many times smaller jurisdictions have little concern for the qualifications of personnel, which were placed in positions of authority."

"The three model codes are up-to-date, but some states and communities fail to adopt the latest addition of the codes. Some code enforcement officers are politically appointed and do not know how to enforce codes."

"National adoption of model codes would be a leap in the right direction. Experienced, properly trained and motivated building inspectors are essential to enforcing that sort of code."

"Wisconsin is very much up-to-date."

"The state of Nevada uses the UBC. It could be improved with more basic research in the area of seismic design."

"Model codes are adequate. Home grown state and local codes seldom are."

"Public hearing and rule-making procedures making updating of rules very slow."

"A problem often arises in the governmental body having jurisdiction over the project recognizing the most recent and applicable codes and adopting or passing legislation that would require their use."

"Building code adopted on state level is fairly current but enforcement is on a local level only and in many areas should be updated."

"Many code changes are approved by the controlling body of model code groups based on improved technology and materials. It is often a delay of several years before the local jurisdictions adopt those changes which could be beneficial to the building process."

f. Owners

"In our highway and bridge work, through the American Association of State Highway and Transportation Officials, we are dealing with the latest and most up-to-date information available."

"Contract with firms that are experienced and that have a good record, pay a decent fee, and provide a reasonable schedule for design and construction."

"In North Carolina they are."

"Except for seismic requirements (and very few agencies of government are required to deal with analyzing the need for often expensive seismic structural requirements as part of building codes, especially in moderate risk zones), building codes, especially the national model building codes, are reasonably up-to-date. No building code can stand alone, or take the place of competent architectural and structural design, where life safety is in question."

"Most building codes are stringent enough to prevent structural failures, but do not necessarily reflect the latest developments in technology."

"Codes are written by committees. Quite naturally, they tend to take a conservative approach to safety standards, and lag behind the state-of-the-art."

"Building codes tend to be conservative and several years behind in allowing new and imaginative concepts. This may not be bad, however, particularly for large structures, as it allows added time for these concepts to be proven out."

"Vermont is currently attempting to adopt a state-wide National code."

"Only significant in fault areas."

"Washington Metropolitan Area Transit Authority (WMATA) designs use the latest edition of codes and regulations. Codes and regulations are up-to-date."

"We deal only in highways and bridges. Our criteria and specifications are generally up-to-date."

"The AASHTO Bridge Code lags technology slightly, but it is certainly not antiquated. The other end of the spectrum is that codes change too frequently and become increasingly complex. This leads to problems of interpretation by practicing engineers."

"The codes themselves are up-to-date. The problem is the interpretation of the codes. They are not black/white. Questions of who is to interpret, uniformity of interpretation need to be examined."

"Codes are up-to-date if the jurisdiction adopts and maintains current publications."

"The Navy codes are more stringent than local building codes in many areas."

"1. Most codes are conservative. Our experience shows that their acceptance of new design techniques and innovations are very cautiously reviewed over long time periods before being adopted. 2. Before new designs are incorporated into building codes, sufficient testing should be performed on models and in the laboratory to validate the design assumptions."

g. Developers

"Codes are close to being up-to-date but have to be evaluated continually to the rapid change in technology and health safety standards. All seismic possibilities should be studied. We need greater emphasis on research in this area."

"Proper inspection and check of str plans."

h. Banks and financial institutions

"Codes are up-to-date, however, the factors of safety are declining to levels that are approaching unacceptable."

"New technologies tend to be tried on a test case basis and then incorporated into codes before the true test of time can take place."

"Adherence is the real problem."

i. Insurance companies

"The geographic area in which we are primarily involved uses 'Standard Building Code' as copyrighted by 'Southern Building Code Congress International, Inc.'. We feel that this code is kept reasonably up-to-date although some times it does lag behind present day technology. No specific consideration is given to seismic events since this code basically covers the southeastern part of the United States where this problem has historically been inconsequential."

"Codes always tend to lag technology because of the bureaucratic way in which these codes are developed and updated. This is not generally a significant problem or constraint."

"No simple answer to this question—minimize building in known subsidence areas, unstable areas (seismic earthquake)—codes inadequate or not enforced—difficult or impossible for erector to meet designer's specs or specs not understood."

"Are written as minimums—i.e., snow load requirements do not include worst case situations."

"Codes themselves are not the cause of structural failures. Enforcement of codes is more of a cause."

"I don't think codes have any impact at all in preventing structural failures except in rare instances."

"There should be one universal code."

7. General Quality of Design

What is your opinion of the quality of drawings and other design documents? Do you see any trends in this area?

How can the quality of design be improved?

a. Architects

"In answer to the question, how can the quality of design be improved? We believe that . . . More pay could attract better talent. More time would allow for more in-depth investigation and analysis. Improved teaching performance would provide better candidates for the profession. The key, however, is to couple all of these with motivation for excellence on the part of the design firm and its individual employees. This must be supported by the owner's commitment to a reasonable standard of care."

"Compared to other civilized countries, the drawings produced in the U.S. are outstanding."

"This is like trying to rate Congressmen . . . do you see any trends in their area? I think most drawings are of adequate quality, but there is no such thing as a perfect set of documents! It behooves all the participants in the total process to prevent errors from being incorporated into the project. However, as far as structural failure is concerned, this is highly unlikely . . . for that kind of error."

"Unreasonable time schedules put more strain on the design . . . and the construction team . . . than all others."

"Quality varies with competence of designer. A careful attitude and a good experienced background of lead professionals should result in excellent drawings."

"The prerequisite for improving the quality design is through the selection of experienced and well-qualified professionals who have good track records."

"As stated earlier, higher compensation for the services of such professionals becomes apparent and essential."

"In addition to monetary adjustments, greater quality control during the design phase as well as the fabrication and construction phase is most essential."

"We do not have many opportunities to look at other A/E project DWG's. When we are asked to observe construction, remodel or make additions to work completed by other A/E's, we have found the structural DWS's to be not up to our standards of professionalism. Lack of details, bad structural design, sheets ambiguous to protect inserts from other jobs—we have one like this in our office now. As a result of our checking, the structural system of this 3-story motel (200 RMs) the S system was changed."

"Most structural engineering degrees (via civil) are heavy in water, sewage, bridge, highways, etc. A structural engineer (via architectural engineering) usually has more input into steel, reinforced concrete design of structures—more prestressed should be given along with actual cases of computer applications. The exposure to architectural design of structures, framing systems actually being used is helpful to young graduating engineers."

b. Engineers

"This varies significantly with different firms. I believe there are more engineering firms today, doing work for general contractors, who are doing minimal design and relying on the practices and procedures of the contractor to "fill in the gaps". This may be acceptable on some work but "habits" *may* be formed that are unacceptable on other work. Competitive bidding will have similar effects of forcing firms to develop short-cutting habits."

"Design requirements today are more demanding, than say, 20 years ago. BEPS, Life Cycle Cost Analyses, FIA requirements, environmental and other permits and more complex "new" projects occur at a time when schedule and financing requirements require shorter time. Costs for remaining abreast are spiraling. On the positive side, computerized design and drafting, construction management, and better management and scheduling techniques off-set increased demands—at a new investment and development cost. The trend of need for greater effort, at greater fees, is obvious. The pressure for competitive bidding, pitting progresive capability against older methods, is contradictory to today's needs."

"Drawings vary depending on different firms, their fee, and the type of project. I believe the quality of work by many firms is not as good as it used to be."

"Drawings by inexperienced engineers are of poor quality."

"Drawings are generally of good quality, but are not as standardized as was the practice several decades ago. Each designer has his own type, and in some cases, the owners (Federal or State agencies) have

special requirements. Generally design drawings do not attempt to follow the builders' practices. Shop drawings are prepared under the direction of the builder so that they incorporate the builders' construction procedures."

"The three suggestions are all worthy goals. We would suggest changing "extend apprenticeships" to "require apprenticeships." If the suggestion of "improve teaching performance" is changed to "require courses in structural failures" we would agree with all four."

"The engineer/architect should not accept a commission unless he is experienced in that field and has sufficient time and fee to complete the project. The owner should select the A/E on the basis of experience and should allow sufficient time for design and construction."

"None of the above. Designs are generally OK. Inspection in the field is biggest problem."

"When adequate funds are available, the quality is usually good. There is a continuing problem in assuming that designers providing adequate information the plans so that the intent is understood by the construction contractor."

"No clear cut answer to this. Again, where fee and scope of work are properly matched through non-bidding selection, quality can be expected to meet industry standards and the standards of professionalism".

"Both time and fee would be critical factors. Again, though, it is not a matter of paying more, but being certain that fee and scope of work are properly matched and that adequate time for performance exists. A relatively small additional expenditure during design can well create very significant savings during construction."

"Though the majority of the design drawings are adequate from construction point-of-view, they sometimes lack in quality and adequacy of details or are not in conformance with the construction techniques employed. In some instances, no consideration is given to the constructibility without sacrificing quality."

"In a majority of cases, not enough time is allowed for the completion of the contract and construction documents, especially so on fast-track jobs. More time generally is desirable to complete the drawings. This, generally, in return will result in added cost. Teaching in the colleges should put more emphasis on details and practical problems."

"Varies with various design firms. Liability problems dictate more care in preparation. Almost all design documents have some errors, most of which are small or insignificant. Usually takes more than one error to cause failure."

"Quality control requires careful attention to details, education of design team to the requirements of the project, review and checking by other than the designer."

"A noticeable and industry-wide continuing trend has been to show less on drawings—this is at a time when many systems become more complex. Educate erectors in reading design drawings and educate engineers in actual field practices. Correct both where in error or confusing. Develop a common approach to documentation. Institute a pre-bid meeting on document interpretation. Request and make contractors liable for not reporting errors they find before or during construction."

"All. Peer review for maintenance of standards and disciplines. Professional accreditation by insurance companies rather than present

system which makes insurance available through a salesman and bases premiums on the number of employees and the volume of work."

"I think this depends to a large extent on the engineer. I've seen many very excellent sets of plans; one can attribute these to the more competent consultants. Others are horrible and show a lack of practical construction practices and even a lack of thoroughness in design. Unfortunately, I'm afraid there are more substandard drawings than there are drawings that meet minimum quality standards."

"I think one should: (1) select on the basis of qualifications; (2) provide an adequate time schedule for a thorough design; (3) negotiate a reasonable fee and a reasonable profit. Unfortunately, the trend in our universities have been reduced. While I recognize the need for the basic humanities, etc., I think actual engineering has been compromised. Further, graduates leave expecting to be accomplished engineers—computer wizards—without any further "nuts and bolts" experience. In this regard, I feel cooperative education helps."

"The trend is that "professionals" are not always there for either design or supervision and production quality control. Drawings by some firms are excellent but, shortcuts are done by undercut engineers—mistakes are made by undercutting engineers."

"This, coupled with intelligent selection—you get what you pay for. This is a factor where low salaries are necessary to stay in business. You sometimes cannot afford to train."

"Most of the documents are of good quality—not excellent."

"The quality can best be improved by increasing the expenditures of design services. If the money is available for design then more money will eventually accrue to universities and other professional training systems."

"We do not know any particular trend in the quality of drawings. We have come across drawings from the low end of the quality spectrum to the high end."

"Quality of design is the responsibility of the structural or design engineer and should always comply with the best current technology."

"Most design documents are of at least good quality. Like any field, there will be practitioners who produce marginal work."

"I personally doubt that teaching in the universities or apprenticeships would have a major effect. Basically, design professionals serve an apprenticeship prior to licensing. Appropriate fees are probably the best warranty."

"The drafting quality is used too often as a measure of structural competence. And most drafting errors are likely to be discovered during construction. So errors per sheet would not correlate with collapses. Any structural office needs good standards for the draftsmen to use, draftsmen who think about what they are doing and a design engineer who sketches and explains details that vary from the standards."

"But pay and time will not compensate for sloppiness, carelessness, or ignorance. First you need the right people. Then they must be free to do what they know is right and to study what may be in doubt. Teaching does an acceptable job for technical aspects of engineering, but few teachers inspire engineers-to-be with the pride and enthusiasm that are so necessary."

c. Construction firms

"Drawings/documents are less complete than 5–10 years ago."

"Owner demands improve quality."

"As general contractors, we see drawings from various architects throughout the area. Quality depends upon the quality of the architectural firm."

"None of the suggested answers will insure an improvement in the quality of design. Only the competency of the designer and his experience can be relied upon for this. I do feel that actual field experience during the apprenticeship program should be part of the educational process."

Design "varies from excellent to very poor."

"Make awards for designing work considering past performance and excellence. Pay for quality."

"Varies directly with quality and experienced of design professionals."

"Getting worse—used to be good—however with more sophisticated structures, new materials architects and engineers are lazy—let others do it."

"Honest work for honest pay."

"Most plans rate fair."

"Many architects and engineers have become lazy—they also have cut their fees so that they neglect to do the work that they should. They cut too many corners on the plans and specs. They are so worried about the legal ends of things that they don't do enough of the true plans and specs—such as details and checking dimensions."

In order to improve quality of design, "make it mandatory for at least two years in the field and make them responsible."

"The quality is generally going down."

"Make the design entity pay for their mistakes."

d. Construction managers

"As in most situations, quality varies from great to dismal. Generally OK."

"For major projects the quality of the drawings are usually good. They are usually oriented to structural details or to construction details."

"Quality of design is highly effected by the professional's awareness of construction practices."

e. State and building code officials

"On many occasions proper information is not easily found in documents and specs to provide direction to builder. Also, builder often does not build as detailed because the detail is not a typical to his operation."

"The additional time for completion of engineering perhaps should be provided by the architect and owner."

"The quality is usually excellent. The problem could be that they become difficult to interpret in the field because the person trying to make the interpretation is not always necessarily qualified."

"More detail should be included on plans."

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"More time should be spent in reviewing and coordinating drawings and specifications between architects and engineers. All architects and engineers should have served time in the field to acquaint themselves with construction problems."

"Generally."

"Many times non-professional plans are so difficult to understand we can not determine what work is being done. It is obvious the individuals have no construction knowledge."

"What needs to be done is that plans for all buildings housing the general public must be designed by licensed designers."

"The quality of construction drawings and specifications content is generally good but occasionally specifications are not updated for current technology and code changes or revisions."

"Schools for engineering and architecture do not stress the use of building and life-safety codes adequately."

"Small building designs are where our division catches more errors. Our state building code, through basic uniformity state-wide, has increased the quality of building designs."

"Standardize structural joinery practices where possible."

"Drawings vary over a wide range of quality. I think this has always been determined by the engineer or achitect; I do not believe there is a trend."

"On large complex structures possibly a team approach to study the loads and the design to assure all loads have been correctly considered to avoid surprises. All team members must be structural engineers."

"Varies considerably. Generally good. When a professional is involved quality is much better."

"Hire professionals."

"Generally quite good after plan checking. Computer drafting is improving quality."

"Improve registration requirements for architects and engineers."

"Structural only—generally deficient from a fire safety standpoint."

"Many times field people have problems if plans and drawings are not of the highest quality."

"Excellent opportunity to bring in qualified working force from the construction trades."

"General lessening of quality."

"Cost to produce each drawing does not often allow the detail as drawings of 40 or more years ago possessed."

"Drawings and techniques vary among architects to some degree but most follow national AIA standard specifications. This promotes uniformity throughout the state."

"Should be mandatory for all architects and design engineers to have actual on-the-jobsite experience certified prior to being allowed to design a project."

"The quality of drawings, clarity and completeness, is a direct function of the professional selected and the depth of review by the reviewing authority."

f. Owners.

"The design should be more organized and controlled with better communications between the engineering fields."

"The quality of drawings and design documents varies widely among A/Es. There seems to be no trend."

"This is more of a consideration of the time element involved than any other single factor. Given sufficient time, all drawings and other design documents can be near perfect."

"The commitment of sufficient time and money will improve the quality. There are designers, however, who can produce quicker and more reliable information and at less cost than others."

"Your quality level is at the highest end of the spectrum because we use competent firms and manage their efforts closely, maintaining constant communications."

"Pay more for engineering. Permits greater opportunity for deliberate thought and consideration of alternatives by higher level members of an A–E firm and improves overall quality of design performers."

"In the last ten years especially, less time has been allocated to proper quality control of designs because of urgency to complete designs in short time frame due to the inflation climate. This has resulted in lower overall quality of design documents."

"While errors may appear anywhere in a set of drawings, the greatest problem is with the lack of detailed drawings and explanatory notes on the drawings. Likewise, specifications are often incomplete. The more that is left out, the more that is left to chance. A mistake on a drawing will probably be detected by someone at some point in the overall process of design and construction. Clarification will often not be sought, however, on matters that are simply omitted."

"Improving the quality of design in an aesthetic sense is a matter for the universities. Improving design in a life-safety sense begins with the universities but can be fully developed only through the detailed study of the codes and standards and the actual application of those requirements and practices to the design of buildings. Preparation time is a key element, but an established checking and review process by several participants is just as important, if not more so, including checking to see that the project is being constructed in accordance with the construction documents."

"Plan drawings are generally very good but the number of errors and/or discrepancies appears to be increasing. This is probably due to less time being available for checking."

"Contract documents are prepared and checked by the designer. They are also reviewed by Washington Metropolitan Area Transit Authority's (WMATA) general consultants and WMATA's own engineering and construction staff. In general, the documents are of excellent quality."

"All of the suggestions given at left may result in improved designs. However, the major factor is the attitude of the person responsible for the design."

"This is our own work. We provide our own drawings and design documents."

"I see no particular trends. It takes continuing training and constructive criticism to maintain good quality plans. Caltrans has the advantage that designers and resident engineers work for the same agency. We have a mandatory rotation program for new professional engineers to expose them to design, construction and maintenance of bridges."

"Enough time should be allowed so that quality is not compromised. Structural design and details should be given an independent check.

Feedback on adequacy of contract documents should be provided by field engineers representing the owner. More on-the-job training would be more effective than revising university curricula."

"I have some concern that greater use of sophisticated computer-oriented analytical techniques detract from the 'feel' for the structure that comes to an engineer in longhand analysis. Engineers should be trained to develop a habit of examining the reasonableness of computer answers and verifying those that look questionable."

"Much improvement is being brought about through computerized design. Plans typically show excellent understanding of building methodology. Prior to new computer applications, plan quality had tended to take a dip over previous years."

"It is felt that design professionals should also be required to have experience in the field, thus providing firsthand information relative to construction process."

"Improving trend. By having people with proven experience perform this work."

"The Navy is in a unique situation in that all plans and specifications are thoroughly reviewed prior to construction. Most of our work is done by consultants, which is reviewed by our professional staff in a systematic manner."

"Quality is extremely difficult to measure; in fact, the Navy has been trying to measure 'quality of design' for a number of years, but many, many factors are involved. Quality control provided by a thorough design/review process, carried out by a professional staff, is the best indicator of a quality product."

"There is an increasing shortage of technical personnel to perform layout, drafting and detail work, also insufficient time to perform these functions."

"In addition, greater involvement by the design engineers during construction is needed."

"Purdue insists on the highest quality. It is impossible for us to generalize about the industry."

"Quality is limited to the extent the designer's skills and knowledge are limited (good designer, good design)."

g. Developers

"Plans are usually of top quality. But there are times in the field that the person interpreting the plans lacks sufficient knowledge."

"Put engineers in field to supervise their plans."

"Not enough time spent in coordination of drawings."

h. Banks and financial institutions

"Plans tend to have less details mainly due to minimizing drafting time."

"The multitude of drawings required on a large job can create some confusion and changes and are not always picked up in all necessary documents."

"Most documents are quite good, but the owner must choose architects and engineers who have appropriate capability for the specific building type."

i. Insurance companies

"Our experience has been that the quality of drawings are generally of a high quality. We find, on occasion, that there is a tendency to

slight the written specification documents and that there is a tendency to bind details of these documents in lieu of placing them on the contract drawings. This practice, in our opinion, oftentimes causes details bound in specifications to be ignored. We are also of the opinion that the present day trends in specification writing tends to make them more general and less specific insofar as the project involved might be concerned."

"On the assumption that you 'get what you pay for,' it is normal to assume that when you pay more for engineering you would receive a higher quality of designs. I do not, however, feel that this is necessarily true. Oftentimes the engineers involved are pushed to meet completion dates which could conceivably cause a substandard job to be performed. Improved teaching and an excellent apprenticeship undoubtedly would improve the quality of designs being prepared. We do not intend to infer that our universities and apprenticeship programs are necessarily inadequate."

"Occasionally there is an item on a drawing which asks for a change since it is unbuildable. The money that often filters to the engineer is often too low and this reflects in the quality of personnel and quality of the service."

"Vary from consultant to consultant and to the time allotted for owner's review. There seems to be a trend toward canned specification. We believe the most important consideration is to allow sufficient time for design and coordination."

"Provide more field supervision—check things more thoroughly at the site."

"Majority of drawings and design documents of good quality. Lack of experience by builder often leads to failure to properly interpret drawings."

"Some increase in conflicts evident over the past years, perhaps indicative of less time available for checking."

"Developers are inclined to not pay properly for the execution of working drawings and for that reason it can lead to some structural deviations in the building. There should be more money spent to do more explicit working drawings."

"Depends on who provides."

"Plans and specifications are generally over-designed; i.e., conservative. Most owners are becoming increasingly concerned about long-term costs, liability, etc., and therefore the communicating same to all parties responsible for a development. Independent third party evaluation of plans and specifications."

"Too often, the greatest problem in design documents is the lack of coordination between architectural and engineering drawings. (See comment number one.)"

"There is a tremendous variation in this matter. Trend appears to be to do less detailing. Designers should be required to have more field experience. Hands-on type of experience would be an excellent addition to formal professional training."

"Some are good, some are bad, it depends on the quality of the people involved. I have seen no trends in this."

"Advent of computer graphics should aid this area."

"Computer-assisted design (CAD) will standardize design documents, and, in most cases, reduce the errors per sheet. Yes, but archi-

tects and engineers must then become more intimately involved in construction, and more specialized in building types."

8. CONNECTION DESIGN DETAILS AND SHOP DRAWINGS

Who should prepare shop drawings of structural connection details? What qualifications should such individuals have? Who should approve them?

What are your suggestions for improving the quality of connection design details?

a. Architects

"The Structural Engineer designs the connection details to be imposed on the connection or joint in question. However, he is not qualified by experience or training to develop fabrication shop drawings as the equipment utilized by various fabricators may differ. The fabricator should, therefore, be responsible for the ways, means and methods of fabricating the materials to conform to the structural designer's requirements. The American Institute of Steel Construction has established standards for various degrees of steel fabrication depending on the complexity of the structure. For example, in any complex structural system, the fabricator should be a Class II AISC Certified Fabricator, which requires professional engineering staff and minimum standards for quality control."

"These are three different questions . . .

(1) The supplier should prepare the shop drawings and submit them thru the general contractor . . . then to the architects/engineer. The G.C. is required to check them first . . . then A/E for review.

(2) The man who prepares shop drawings should have a clear understanding of his own products and the design drawings from which he prepares them. He should seek information if any is lacking.

(3) The structural engineer should check, or supervise the checking of shop drawings."

"Sometimes, in more complex projects. But checked by the structural engineer."

"Have them certified by an independent engineer . . . or by the structural engineer."

"Have the fabricator retain a licensed structural engineer . . . this is good, for complex jobs."

"Design drawings and specifications should clearly convey to the contractor the basis of design and show special connection details that do not fall under established standards of the industry."

"Since shop drawings are needed by the fabricator to fabricate and erect the facility, those drawings should be prepared by experienced engineers employed by the contractor. The detailer should communicate and develop the shop drawings in cooperation with the design engineer. The shop drawings, regardless who prepares them, *must* be reviewed by the design professional to ascertain the proper interpretation and execution of the design."

"Most structural draftsmen can prepare shop DWGs for the more simple structures—but a licensed design engineer should place his stamp, sign and date it on *all shop DWGs* regardless of simplicity—he

should be responsible. The fabricator should have a licensed qualified structural engineer check and stamp any DWGs prior to issuing to the architect—especially if the architect does not have in-house structural design capabilities."

b. Engineer

"Standard connection details are considered part of the fabricator's 'product' because various shops differ in their equipment and corresponding methods for developing connections."

"The fabricator should employ a licensed structural engineer who is responsible for the shop drawings. The architect should employ a licensed structural engineer who is responsible for approval."

"Structural engineer should be licensed. They should design and approve connections. Any experienced person working for the fabricator could prepare the shop drawings."

"All design should be performed by a professional engineer licensed by the state."

"Check by all parties using an engineer."

"Because satisfactory structural connections can be made in several ways, the contractor should have option to choose which way. Only when it is vital to the general design concept should the structural designer show the detail on the 'bid' plans. The structural connection should be prepared under the direction of a competent licensed engineer and reviewed by the structural design engineer."

"Any of the three methods suggested (have them certified by an independent engineer, have the structural design engineers do the details, have the fabricator retain a licensed structural engineer) are good. The third seems more logical since the structural engineer retained by the fabricator would be in a better position to design the efficient detail. (He would be knowledgeable of the fabricators' equipment and procedures, while the structural design would not.)"

"Shop drawings should be prepared by the contractor/builder and submitted to the A/E for review. Review should be performed by the engineer who prepared the drawing (that is structural shop drawings, by the structural engineer, HV by the mechanical engineer and electrical by the electrical engineer)."

"All structural connection details should be done by the fabricator, who should submit them to the contractor, who then submits them to the structural engineer to review."

"Structural engineer should be paid additional fee to review shop drawings in detail."

"Have fabricator retain a licensed structural engineer——" This would give a double check on the original design."

"The person with the final responsibility for approval should be a licensed structural engineer who is thoroughly familiar with the design."

"If the fabricator is to be held responsible for the connection design, he should retain a licensed structural engineer or the builder should engage an independent licensed structural engineer to assume the responsibility."

"We need a Federal statute requiring the structural, electrical, and mechanical engineers to certify that all shop drawings conform to the appropriate building code."

"Traditionally, submission of shop drawings should be the responsibility of the contractor who often draws upon suppliers and fabricators for details. The engineer's responsibility is to review shop drawings for general conformance with design, but not to assume responsibility of contractor. Again, this is clearly and correctly spelled out in ACEC standard documents."

"Connection design details are normally a part of the design documents. Connections are an integral part of a structural design. Certification is not an answer since it usually nullifies errors and omissions insurance carried by most designers."

"The fabricator should get the shop drawings prepared under the direction of a registered engineer. Shop drawings should be reviewed by the project design engineer."

"The fabricator should retain an experienced licensed structural engineer to prepare the connection details. However, the structural design engineer should provide adequate information on the drawings so that misinterpretations do not occur."

"The shop drawings should be checked for conformance to plans, by the engineer. The builder should be responsible for approval to incorporate in the work."

"Shop drawings should be prepared by the qualified fabricator and verified by the structural engineer. Again, past performance is a better criteria for contract award than low bid."

"Best to have someone other than the design engineer involved. As the fabricator's engineer is detailing the job on shop drawings he is checking the design engineer's work. The roles then reverse when the design engineer reviews and approved shop and installation drawings."

"The person should preferably be an engineer; more importantly he should be able to read and interpret plans; be familiar with practices in the shop for which he is detailing, and have a basic understanding of the reasons for the details and the detailing guidelines and specifications."

"1. Basic design details prepared by engineer. 2. Shop details prepared by fabricator (competent person). 3. Shop details checked by fabricator. 4. Final check by desig . engineers for materials, workmanship, and meeting design plans and specifications."

"Our system works fine. An experienced detailer prepares shop drawings. The structural engineer is always then responsible for detailed checking."

"The detailer should design only standard (A.I.S.C., if steel). Details as specified by engineer. Standard practice is that the engineer designs details—detailer provides cut lists, fabricator, information only."

Shop drawings should be prepared by the fabricator. I believe these drawings should be produced by licensed, experienced structural designers."

"The fabricator must employ licensed, experienced structural engineers."

"Shop drawings should be prepared by an experienced technician: but they should be checked and approved by the fabricators licensed engineer prior to review by architect and structural engineer."

"Fabricators with qualified structural engineer supervising should prepare shop drawings of structural connection details. The structural

engineer who designed the structure should approve the shop drawings."

"If connection design details are prepared and approved as described in the above item their quality will improve."

"Fabricators can do this but should be licensed engineers."

"Most shop drawing details are routine and each stop has standards that suit its operation. So long as they meet the requirements of the contract documents and the documents are complete, there should be no problem. The design engineer must check the structural aspects of shop drawings, but the courts have made "approve" a bad word. Our insurance company doesn't want us to use it."

"The design documents should be clear as to what is required and any non-standard connection should be detailed, showing design loads where the solution is flexible. But these details should not become shop drawings. The fabricator must be free to detail in a way that suits his operation, providing the forces are all accounted for. Certification and licensing are only make work projects and will not help."

c. Construction firms

"Shop drawings showing structural connection details should be prepared by the fabricator and then checked by the structural engineer. Any experienced person could prepare these connection details but their adequacy of design should be the responsibility of the structural engineer in checking the shop drawings. In the case of non-standard connections, the structural engineer should make them a part of the design documents. The structural engineer should have the responsibility for checking that the standard connection details selected by the fabricator are adequate for the design loads anticipated and called for on the documents: all non-standard connections should be detailed by the structural engineer."

"Design engineer should approve them."

"Fabricator prepare (drawings) and approved by structural engineer."

"Fabricator prepare—engineer approve."

"The bid drawings should show details of structural connections."

"Fabrication should do only those which are standard. Any connections which are special or unusual should be detailed by the design engineer, not just checked. Designer should still be responsible for adequacy of each connection and should verify same."

"Regarding suggestions for improving quality of connection designs, 'This must be kept between the designer and fabricator. The end result is a blend of the fabricators practicality and workability with the design requirements.' "

d. Construction managers

"Fabricator should prepare shop drawings in coordination with structural engineer. Architect needs to review."

"Any special structural requirements or connection details should be spelled out on the drawings by the structural engineer. The fabricator can provide the typical connections that is those that is standard in the industry. The design engineer has to take the responsibility for approving all connections."

e. State and building code officials

"Adhere to the standard building practices with the checks being done. When varying from the standard establish additional checks to assure that all parties have had the opportunity to review."

"The structural engineer either employed or contracted by the fabricator."

"The more the review the lesser the chances for total failure."

"There is nothing wrong with the detailer for the fabrication preparing structural connection drawings provided the detailer is either a licensed engineer or working under the supervision of the one who is licensed. In any event the approval should be that of the Design Engineer."

"Licensed architects and engineers should prepare the subject material."

"Prepared by fabricator (experienced person or licensed engineer); checked by contractor, structural engineer, architect."

"Prepared by fabricator under supervision of registered engineer and approved by design engineer."

"Structural engineers should be professionally certified and periodically tested for competency and technological change. The plans reviewer should approve the engineer's drawings, and he too should be certified and up to date on the state-of-the-art."

"The problem more often is in short-cuts in fabrication of structural components, poor installation and deviation from plan specifications."

"I believe the structural engineer repsonsible for design on the connection is the best qualified person to draw the detail; however, a fabricator should be able to prepare shop drawings from the original design drawings. The structural engineer should approve the shop drawings."

"Generally the fabricator; however, if the designer wants a specific design he must detail."

"Prepared by the fabricator. Approved by the general contractor, the architect and his structural engineer."

"Adequate plan checking and approval by architect and his structural engineer."

"Improvement not needed if reviewed by design engineer."

"Third party could solve problems while in the planning stage."

"Licensed structural engineer, other than design structural engineer, should prepare shop drawings to be reviewed and approved by design architect and design structural engineer."

"Traditionally, it is the responsibility of the fabricator to prepare the shop drawings because the fabrication procedures are tied to the fabricator's methods and procedures; however, the shop drawings must be approved by the designer for adherence to the design and by the reviewing authority for code compliance."

f. Owners

"One who is proficient in structural detailing. A qualified engineer should be required for approving."

"In our work, we believe the fabricator should prepare shop drawings so that the detail may better fit his shop practice. All details, i.e., shop drawings, are reviewed and approved by the designer. We have firm criteria for structural connections and these must be adhered to regardless of who does the detail work."

"In our work, we feel the quality of this detail work is satisfactory and we envision no change at this time."

"The fabricator should be a licensed engineer on his staff that would prepare the shop drawings. Approval should be by the structural design engineer."

"Use of standardized connection details."

"Fabricator should prepare shop drawings. Structural engineer should approve."

"Assuming the connections are not detailed on construction drawings. If detailed by a licensed engineer on construction drawings, then an experienced structural detailer could prepare shop drawings for the fabricator which should be checked by a licensed engineer."

"Shop drawing preparation is a contractor function and responsibility. They should be prepared under the direction of an engineer and checked and approved by the structural engineer responsible for the design."

"It is common practice in the East Coast for the contractor to provide design details for connections based on stress diagrams furnished by the design structural engineer. This is poor practice. All details should be provided by the design structural engineer responsible for the project. This is the general practice in the West Coast, especially in areas of high seismic risk."

"The present arrangement calling for designer (engineer or architect) prepared drawings to be modified and resubmitted as necessary by the fabricator works well, so long as the designer thoroughly checks the work (shop drawings) prepared by the fabricator."

"Require in each state a separate classification of engineer—that of structural engineer—and place in the university curriculum and subsequent apprenticeship the content to develop the knowledge necessary of structural detailing. Some states have done this to varying degrees. Preparation to be a structural engineer has not received the degree of specialized training that ought to be present, however."

"The fabricator normally prepares shop drawings. Review should be done by the design engineer for the project."

"The shop drawings should be prepared by the fabricator and always checked and approved by the structural design engineer. Both of these should be licensed engineers."

"Complicated details should be prepared by the designer, a registered professional structural engineer. Simple conventional connection details may be left to the qualified fabricator. All shop drawing details should be reviewed and approved by a licensed professional engineer."

"All of the suggestions on left and prequalification of the fabrication could improve connection details. The most significant means of improving any design details would be to have them prepared under the supervision of a registered professional engineer and fabricated in accordance with design."

"Shop drawing of connections should be designed by a licensed engineer employed by the fabricator and reviewed by the design engineer who should also be a licensed civil engineer."

"On Caltrans projects, connection details that are designed by the fabricator are reviewed by the design engineer."

"Varies greatly among firms."

"Shop drawings specifically dealing with the structural connection details should be detailed on the design documents, not left to the fabricator. The fabricator, however, should provide shop drawings to the architect/structural engineer for clarifications prior to fabrication."

"The structural engineer should design and detail complicated and unusual construction details. The fabricator should then provide shop drawings for the engineer to review."

"In addition to the previous answer, the fabricator and/or design engineer should always consider constructability and learn from experienced field engineers."

"Structural steel connections are generally designed and prepared by the steel detailer. Loads and reactions are made available by the designer and details should follow the Authority Standards and permissible stresses which are furnished to the Contractor in the Contract documents. Complex and unusual connections are detailed completely or in part on the Contract Drawings."

"The fabricator retains a structural steel detailer who is experienced in preparing structural steel connection details, preferably having experience in Authority work. The detailer should be a licensed engineer."

"All structural steel connection details are approved by Transit Authority engineers for strength."

"All structural details, in our organization are checked by structural engineers and approved for strength prior to fabrication. Structural Engineer must have structural detailing experience."

"The fabricator should prepare shop drawings to be approved by the licensed structural engineer who designed it."

"Hire only experienced, qualified architectural/engineering firms."

g. Developers

"The fabricator prepares shop drawings and the person responsible for the plans should review—correct and approve—such as the structural engineers."

"They should be inspected by an independent testing (engineering) lab—and tested."

h. Banks and financial institutions

"This is the engineers responsibilities. All re-evaluation by another professional could be self-serving."

"Shop drawings should be checked by structural engineer."

"The fabricator's licensed engineer should prepare, and be checked by the structural design engineer and architect."

"A thorough set of shop drawings and checking procedure is required."

i. Insurance companies

"We are of the opinion that shop drawings should be prepared by the fabricator. They should be checked by the erector, the contractor, the structural engineer, and the architect. Needless to say, an experienced person should prepare the shop drawings from adequate instructions furnished by the engineer. Shop and field connections should be designed by the structural engineer, detailed by the fabricating contractor, checked by a licensed testing laboratory."

"Checked and approved or disapproved by the structural engineer."

"Have the details checked by the engineer of record and not by the office boy—as often happens."

"The fabricator should prepare the shop drawings based on the engineer's plans and specifications. Final approval should come from the structural engineer."

"Just allow more time for the normal process."

"Considering the evolution in construction techniques, require all parties involved in construction design details attend mandatory seminars at some pre-determined intervals."

"Approval by structural engineer of record and contractor."

"(1) The engineers employed by the architects; (2) track record and professional qualifications; and (3) the architect and improvement owner/developer."

"A licensed engineer, whether it be the structural design engineer or the fabricator matters not. I am of the opinion that what is important is that the structural engineer should be required to place his final stamp of approval, again, not just reviewed, on the shop drawing."

"Details of connections should be part of certification process of structural designer. It is the most important part of the design."

"Not a fabricator's draftsman."

9. IMPACT OF HIGHER STRENGTH MATERIALS

What impact does higher strength materials have on the need for more careful design and construction techniques?

a. Architects

"In general, higher strength materials are more brittle and, therefore, more susceptible to damage if improperly handled or subjected to unforeseen impact. Additionally, it is difficult to distinguish between a high strength material and a lower strength material without special training which could result in improper use of welding rods, bolts, etc."

"Higher strength materials, in a structural sense, usually mean smaller members for the same load and span-length. This can result in more deflection, and also requires more careful attention to connection details. Herein lies the need for experience and good judgment."

"Use of computers, especially in the hands of inexperienced designers, has contributed more to the design problems than use of higher strength materials."

"Use of computers has made designs more sophisticated and exacting not leaving any room for oversight. This becomes more critical when canned programs are used without built-in checks and controls. The bottom line for all of this is experienced good judgment and common sense."

b. Engineers

"Higher strength materials require more careful design since our experience backlog with these materials is not as high."

"Higher strength materials shouldn't increase the need for careful design and construction techniques as long as other parameters stay in the same proportion."

"It is not so much the higher strength of the materials but the loss of ductility, toughness and stiffness which accompany the higher strength that cause the problems. Also, design procedures have become more

sophisticated, permitting the designer to be more 'exact'. The combination of these factors makes the structure less 'forgiving'."

"The use of higher strength materials requires the use of specialized construction techniques which may not be understood by the contractor builder. These materials also permit the use of lower factors of safety."

"Structural engineer should be paid additional fee to review shop drawings in detail."

"Higher strength materials are OK if proper quality control is exercised during manufacture."

"Higher strength materials normally require very careful quality control since they permit thinner, more compact sections."

"I see no real difference in design core. Higher strength materials simply provide a means for lighter and more innovation design, but the basic procedures remain unchanged."

"Higher strength materials, if designed and used properly, result in adequate and satisfactory design. However, their properties are sometimes affected by the way they are handled, mixed, cured, placed, fabricated and installed. This calls for trained personnel for proper execution."

"Each structural element is more important when there are fewer elements."

"We are slow to relearn. An individual who has performed his task for years according to an unchanging formula or standard tends to continue those successful habits even though he now handles newer materials with difference performance characteristics. Today architects, engineers and contractors must be aggressive in their determination to maintain pace with exploding technology."

"Design and construction techniques should be first class regardless of materials; one should be aware, however, of increases in critical fracture qualities of high-strength materials increased deflections, etc. This is all inherent in careful design."

"High strength materials are designed to the same (appropriate) factors of safety as those of lower strength."

"The education of designers and constructors must be continually updated in order to keep up with the state of the art relative to construction materials properties."

"Probably none."

"Design and construction personnel using high strength material should be knowledgable about the limitations and drawbacks in their use."

"Greater care is needed to be sure the materials conform to the design. There are more numbers for clerical errors and more confusion. In design, it is easy to disregard factors that were unimportant at lower stress levels. Torsions, defections and buckling all can be far more critical."

c. Construction firms

"None. Engineers need to be familiar with materials."

"The design engineer needs to keep up with technology."

"Training or familiarity with product is required."

e. State and building code

"With the reduction of safety margins all persons involved in the construction must be properly trained."

"Architects, engineers and contractors have to be aware of the limitations of structural materials incorporated in the design."

"By use of 'high strength' materials the designer could become overconfident in the mere 'high' strength of the material and not run the appropriate structural checks."

"All should apply. Tolerances are sharply reduced; need for specialized training for construction labor; facilities must be certified for specific use and conveyed by title."

f. Owners

"The design engineer must have a thorough knowledge of the materials to be used. The impact would be determined by the materials characteristics."

"Higher strength materials can cause changes in procedures previously accepted. It is necessary to carefully give consideration to all aspects of this new material. Deflections and new types of secondary stresses can arise which previously could be ignored."

"Because of the use of high strength materials, permitting higher stresses, the need for a close check on deformations becomes much more critical. Most high strength materials do not possess the ability to resist greater deformations proportional to the ability to resist higher stresses. Most steels possess no increase in deformation capacity with increase in allowable stresses. This could cause possible secondary stresses if not checked. Greater need for quality control during construction."

"Very little as long as the limitations of the higher strength materials are recognized. Using higher strength materials will of course require additional precautions and calculations in design."

"High strength steel such as ASTM A514 requires much more care during fabrication than the more common ASTM A36. Special training is required for welders and inspectors. This situation may be typical of other high strength materials."

"High strength materials require accurate engineering, constant inspection for adherence to details, and lab testing as required."

"Design engineers must keep up with the 'state-of-the-art' and understand the special considerations and peculiarities of high strength materials."

"The use of welding on high strength material must be carefully analyzed and evaluated as welding generally changes the strength of high strength materials."

"This is for the designer to establish."

g. Developer

"Engineer on site."

h. Banking and financial institutions

"Tolerances are reduced but not sharply."

i. Insurance companies

"The use of higher strength materials should have little or no affect so long as all involved are aware of the higher strength materials and the above procedure is followed."

"Training is fine but jobs must be properly supervised and if complex, should have engineering input on a regular basis."

"Requires the design engineer to have more detailed knowledge of the material and its properties, rather than rely on experience and standard practice. Tolerances could be either design or construction tolerances, and the margin for error is less due to more restricted tolerances."

10. POTENTIAL FOR IMPROVING QUALITY DURING CONSTRUCTION

What suggestions do you have for improving the quality control of structures during construction?

a. Architects

"Utilize qualified testing laboratories who are by training and experience and equipment qualified to verify that the details of the designer have been followed utilizing the quality of materials specified, quality welds by qualified welders through the use of magnaflux, x-ray or ultrasound testing which the laboratory deems appropriate."

"Field inspectors should be either specially trained or EIT's or PE's."

"This is a requirement for *all* the participants in the total project . . . architect, engineers, builder, inspection team . . . *all* must have on-the-job training as *junior* people under experienced, qualified lead people to gain the knowledge."

"Place greater emphasis on shop and field inspection and quality inspection through qualified and licensed testing laboratory people."

"Unqualified personnel many times are involved in conc testing, rebor inspection, steel conn inspection, a qualified, registered structural engineer should be accountable for controlling the quality of the structure during construction."

b. Engineers

"Provide full-time resident engineers on the job site. Should be employed by either the owner or A/E."

"Insure a consistent level of inspection and insure inspectors have proper training."

"The American Concrete Institute has promoted schools for concrete inspectors for years. They have also tried in vain to train contractors' personnel. Proper education and training is the best way to improve quality. It must be supplemented by encouraging all concerned to care about the quality of "his building"."

"Establish one individual authority and provide him with the necessary power and authority to oversee the project."

"Provide full-time resident inspection by design firm."

"Use structural engineer as inspector."

"There should be one person responsible who is a licensed structural engineer and is engaged by the owner rather than as a subordinate to the contractor or designer."

"We need a Federal statute requiring the structural engineer to design all construction schemes, then certify that they were followed."

"In Federal projects the designer is not usually consulted during construction, which can many times result in improper construction, which can many times result in improper interpretation of design, uncoordinated changes, etc. Various branches of the Armed Services

maintain their own inspection teams, for example, and this can result in construction problems."

"Field inspectors should be fully qualified to do the inspection to ensure quality control. Though one individual may be accountable for overall quality control, it is essentially a team effort and all individuals involved in the process should be fully qualified to do their duty."

"Inspectors must be trained and certified (office, school) and be skilled in their observations."

"Here we need a change of attitude and vocabulary in addition to better education and exposition of quality standards. Instead of least-cost—economics. Instead of liabilities—responsibilities. Instead of quality (cosmetic, taste)—quality—(systems, safety, solutions). Instead of consultants—agents. Instead of control—management."

"1. Adequate specifications spelling out required quality control. 2. Adequate inspection of construction with personnel trained to enforce quality control. 3. Prompt reporting to resident engineer of questionable practices or observed deficiencies. 4. Prompt action by resident engineer to correct."

"1. Make every effort to define the requirements for field quality control. By law—local code, etc. 2. Design engineer or his designate should be required to to follow with quality control as per the above."

"All quality control during construction must be employed and paid for by the owner. Contractors must not be allowed to provide their own quality control. (It is the practice of most Federal agencies to require the contractor to furnish quality control—this usually results in the employment of a "low bid" agency and often poor quality of construction."

"1. Under any circumstances, field inspectors should be well-qualified. 2. There should be work continuity between design and construction. Designers should have an opportunity to visit the job when they feel it is necessary."

"Having qualified and experienced field inspectors, and close working relationship between the builder and the design engineer should improve quality control of structures during construction."

"A good engineer with a knowledge and feeling for structures and the sense to insist on doing what is right is the most important factor. And he needs the time to think about, evaluate and check out possible problems. Designers and draftsmen would work with him, but one structural person is needed as a focal point."

c. Construction firms

"Do not give the unqualified and inexperienced inspectors authority to approve/disapprove on judgement situations."

"It has been my experience that most field inspectors do not have a good structural background and therefore, need special training as to what to look for during their inspections and why it is important to the structural integrity and placement of steel and reinforced concrete. It is important."

"Qualified people accountable to owner or his representative (architect)."

"The building team—architect, engineer and contractor—should accept this responsibility."

"The design entity should be responsible for field inspection—the AIA contracts have been changed in recent years to eliminate this responsibility."

"This really needs to be done at design phase via quality drawings, quality details, and clear specifications. If properly done on contract documents a responsible individual can insure compliance with contract documents without a vast expansion of paperwork."

d. Construction manager

"The QC individual must have the authority to control quality."

e. State and building code officials

"Unless a construction representative fully understands the construction process then he should question procedures that appear to not follow design intent or construction practices."

"There should be a designated and accountable "Quality Control" inspector at the site during construction. If properly applied, this practice could significantly reduce problems."

"Inspectors must be aware of the importance of their role when structural engineers are not employed on smaller construction projects. Lending institutions might coordinate their payments to follow approved inspections."

"Field inspectors must have engineering background for large complex high rise buildings. He must be able to determine construction is in compliance with the approved design."

"Pay for engineering inspection services."

"Retain qualified architects and engineers. Utilize independent testing laboratories to check the contractor's work and have qualified field inspectors."

"In many instances the field inspectors are trained in fire prevention code enforcement, not building design and structural requirements."

"The quality control individual on the project should be certified by a nationally recognized agency in the related field (ICBO, U.L., etc.)."

"There should be only one individual with overall accountability; however, he should be supported by inspectors who are knowledgeable in their area of responsibility."

f. Owners

"From previous experience construction meetings with the A/E, contractor and contracting officer have proven to be beneficial. Meetings should be at least monthly."

"The West Virginia Department of Highways feels that it is in the forefront of quality control among all the states. We are assured through all material, fabrication and work accomplished, that it is in strict conformance with the requirements of the contract. Schools for field inspectors is an important part of this procedure. Quality control and production should be separated as far as possible."

"Inspectors should be licensed engineers and at the site full-time, while foundations are formed and placed, while steel erection is ongoing, and when structural floor slabs are placed. The paperwork should be limited to site only where the activity is located and any rejection of the work."

"Provide for site visits/inspections by responsible design engineer during installation of primary structural systems."

"Simply use the procedures and practices that are customarily part of the present construction process. Sweeping change is not necessary. Problems arise when shortcuts are taken and one or more of the time honored, normal aspects of drawing preparation, inspection or construction are ignored or compromised. More uniform requirements for construction inspectors would be helpful but before that should come the requirement for inspection during construction which is presently not, as stated above, a part of statutorily required architect/engineer services."

"Supply adequate field supervision in both numbers of inspectors and in construction expertise."

"Quality control is the responsibility of the fabricator. Quality assurance is the prerogative of the owner. The fabricator must have a strong quality control group who should report directly to the plant manager and should not be accountable to the production group. Again, the design structural engineer should review construction at critical junctures."

"Due to the rise in inflation in recent years, there has been increased emphasis placed on minimizing both the design time and the construction time of major facilities. This is not necessarily good as quality can be sacrificed if the "urge to complete" becomes the overwhelming criteria."

"Stricter enforcement of contract requirements will improve the quality of structures."

"Projects involving major structures should be staffed with inspectors and a resident engineer that are highly trained in the type of work being done. The project designer should review shop plans, erection plans, etc., to be sure that construction stresses will not be excessive."

"Adequate intelligent inspection."

"On larger projects the Navy utilizes a Contractor Quality Control system, whereby the contractor is responsible for most approvals and quality of construction, and hires an individual to fulfill that objective. On other contracts, trained government inspectors are continuously educated to help them perform their duties."

"Also greater involvement by design engineers."

"Purdue uses qualified inspectors and qualified design firms. The suggestions listed would not add much to the quality of construction on this campus."

h. Banks and financial institutions

"Select good general contractors. Have architects and engineers inspect periodically."

"Inspectors are usually tasked to do limited inspections, therefore, there can be a number of inspectors on any one project based on complexity and project size. This being the case, all reports should be monitored, evaluated, and accounted for by a qualified central service or person."

"The building officials should require the owner to retain certified testing labs to inspect critical areas during construction and lab-test certain critical connections."

i. Insurance companies

"Needless to say a qualified superintendent should be on the job site at all times. If the work has been properly engineered, properly shop-inspected and field-inspected, you have done about all that can be done to insure a quality construction job."

"Employ good capable architects and engineers."

"Have qualified inspectors completely familiar with design criteria and concepts."

"This individual (meaning quality control manager) should have an adequate and capable staff."

"Enforce existing plan approval, shop drawing approval, change order approval, and permit approval processes in compliance with sound engineering practice."

"Our company receives all structural and test reports of construction and structural systems of the building."

"I would suggest a required certification program for field inspectors. Such a program could be handled similarly to that of state licensing of architects and engineers. A certified inspector should then be required for all projects of a certain dollar amount and size or above. Other criteria, such as public welfare, could also be included."

"Training for quality control is a special area of knowledge and responsibility."

"Closer and more frequent inspections of work in place."

"Having QC report to lending institution is already a standard practice."

11. ADEQUACY OF STATE AND MUNICIPAL DESIGN REVIEWS

How effective are State and municipal building departments at verifying the adequacy of design and the quality of construction?

a. Architects

"Large cities usually have people who are competent to verify adequacy of design. Small cities and counties usually do not have graduate engineers or architects on the building inspection staff."

"The volume of work, and the salaries and number of people to adequately do this work, is too great to expect them to do it. Some larger cities/etc. have excellent people . . . others marginal. They should required adherence to codes by A/E and contractors . . . and not be responsible for the check. Requiring a licensed structural engineer's seal on the design documents should be satisfactory."

"Prior to 1975, NJ used to have a Bureau of Engineering and Safety, Department of Labor and Industry—it provided excellent public safety in reviewing and approving building plans and specs. It was eliminated to "save money", much to everyone's regret. We definitely should have it back, and similar in every state."

"State and municipal building departments, even if they would have the proper staff to go through the total design, should not be held responsible for the adequacy of design. Such involvement would create confusion and cause delays."

"The primary function of building departments should continue to be to establishing basic parameters and guidelines to use in the design."

"Most agencies are understaffed w/quality professionals due mostly to salary levels for structural engineers. Some field inspectors are not qualified for structural inspection."

b. Engineers

"Most municipal inspection do not have experience with heavy construction unless it is a city with engineers in the building department."

"The competency of the building departments vary depending upon the individuals they employ. Because of the political nature of the work, it is hard to hire and keep top quality engineers who must be jacks of all trades. The building department engineers cannot be expected to be fully conversant with all the latest technical developments and they certainly cannot be expected to have the time to spend in a detailed review. Their review must be broad and general."

"Most state and municipal departments do not assert their authority and/or responsibility until after a failure or situation has occurred."

"This varies widely between municipalities and between departments within state governments. While occasionally it is a matter of competence, the overriding problem is inadequate staff."

"This verification should be the responsibility of the second set of structural, electrical, and mechanical engineers."

"A situation which frequently develops is review being accomplished with less experienced personnel than those originating the design. When this is combined with authority to dictate design, trouble can result and there is no clear-cut assignment of responsibility. The design professional is often precluded from exercising his professionalism."

"Majority of local building departments review documents for adherence to codes only and rely on the design engineer's end product for compliance with contract documents. They do not perform any detailed analysis for adequacy of design or structural integrity."

"Architect/engineer inspector should verify the construction quality. Design engineer should be responsible for the design quality (adequacy)."

"Municipal construction inspectors are concerned only with code compliance questions and codes do not deal with modern construction technologies—building departments generally defer to the structural engineer. Inspectors are often not knowledgeable—their experience, which qualified them for their jobs may have been in wood frame, single family house construction but, they are then assigned to inspect structural steel, high-rise installations or even more exotic concrete shells, cable suspension structures, etc."

"On large unique projects, I think they are ineffective. On smaller projects (run of the mill), probably okay but this varies markedly from state to state. Most are there to measure pay quantities and little else."

"This engineer, having experience over 15 years on $500M in construction has *never* seen effectiveness (of any kind) in building officials expect in other countries and even they are limited."

"In general such departments are ineffective particularly within the southeast and southwest."

"Generally complies with the state laws governing the site of the work. Various state laws differ."

"Varies widely from very competent to incompetent. However, they really should not have to verify design if done by professionals."

"Building departments are not able to establish a capable staff of structural people and generally cannot obtain a budget that allows them to hire consultants. The fees they collect are a tax and the politicians do not get votes by improving a building department. So they spend the money on giveaways to voters."

c. Construction firms

"For the most part, building departments do not employ licensed structural engineers capable of verifying adequacy of design on any project. I do not feel that this is the responsibility of the building departments and should not be a burden to the taxpayer to employ this type of highly qualified individual."

"Again, I say, make those who are responsible in charge—if they have no responsibility—get them off the job."

d. Construction managers

No responses.

e. State and building code officials

"This is the responsibility of the designers, the state or municipal building departments have review of the designer work only from a concept and procedural standpoint. To do other than that would slit the responsibility and erode the designers authority to do his work."

"This is a field of specific expertise. Some states and the municipalities within those states are highly qualified and do a superb job. Other states and the municipalities within those states have no concept of how a building department should function. If there was ever an area that varies widely, without doubt, this is the area."

"We are constantly trying to upgrade our inspection forces to insure quality workmanship. Design review is dependent on checking for code compliance."

"Depending on qualifications of staff, adequacy in number of staff, and politics the effectiveness varies."

"Idaho is voluntary with regards to code enforcement for all but state-owned buildings."

"Smaller jurisdictions have generally less professional staffs and are less capable of reviewing larger more complex plans."

"The first line of defense needs to be the designer/supervising professional. State and municipal inspectors are secondary but needed to insure the first."

"The design and quality of construction of State projects in Nevada is carefully controlled."

"Code enforcement personnel cannot verify *design*, only adherence to the Codes. It is the responsibility of the designer, or structural engineer to satisfy demands for adequacy of design and quality of materials specified and/or actually used."

"Many municipal agencies do not pay enough to retain the most experienced person, engineers and architects in the review process."

"Many local building officials in our rural areas have had very little formal training and have not been certified."

"In most building departments the primary responsibility of the reviewer is to assure that the applicable codes are met, and it is not their responsibility to verify the adequacy of the design."

f. Owners

"In West Virginia, the Department of Highways feels totally qualified and effective in the administration of highway projects."

"Except in large cities, most building departments do not have a structural engineer who is qualified to check structural design."

"Small municipal jurisdictions tend not to have well-qualified inspectors, compared to larger cities and counties. States typically do not have 'building departments,' but have professional staffs to review design and construction of state-owned projects only."

"Washington Metropolitan Area Transit Authority consultants are responsible for the quality of design and construction. Local building departments review the design only. Construction inspection is provided by WMATA's General Construction Consultant. Local building departments have recognized such procedure. On this basis, no additional inspection is provided except in special cases."

"They generally rely on the professional engineers' certification of structural adequacy."

g. Developers

No responses.

h. Banks and financial institutions

"Projects are not always built as designed so initial design approval by municipal authorities is not always meaningful."

"State and municipal building departments need to take responsibility for what they do if they are to be effective."

i. Insurance companies

"Too often state and municipal building departments exist solely for the collection of building permit fees. This condition exists primarily in smaller communities. Larger municipalities tend to have adequate inspection forces but too often their qualifications are that of a journeyman, tradesman or less."

"Varies from city to city. Generally they have not the staff to properly check construction."

"The most important testing and quality control is done at the expense and under the control of the owner."

"Inspectors generally have little control of quality as long as it meets code requirements."

"Bureaurocratic bunglers!!! Generally incompetent and underqualified if qualified at all! There should be licensing history bureau to certify all key officials and inspectors with periodic updates, just like architects, engineers, etc."

12. INCREASED USE OF SPECIALTY CONTRACTORS

When using greater numbers of specialty subcontractors, do you find this increases the complexity of project communications and can this contribute to structural failures?

a. Architects

"Any job involving more specialties becomes more complex, and, therefore, increases the complexity of project communications. The key ingredients, however, are whether Specialty Subcontractors are qualified and responsible or whether they are fly-by-nighters in the business for the sole purpose of making a buck. Qualified and responsible Specialty Subcontractors can be a tremendous asset to a project, whereas unqualified and irresponsible Specialty Subcontractors are a serious hazard."

"The more complex the project, the more possibilities of error . . . but, there again, is the requirement of experience . . . which should prevent the likelihood of anything so drastic as structural failure."

"Reduces likelihood of failure . . . assuming competent specialty subs."

"Any major project is designed and built through the cooperative effort of all qualified parties. As long as provisions are made and people assigned the responsibility of quality control, proper communication and coordination, introduction of specialty subcontractor needed for a special purpose should not give rise to failures."

"In simple, small projects, no. But in large hospital additions and remodeling, coordination is very difficult for the architect who does not have in-house structural capability. The greater the responsibility for closer coordination of all professional, and trades—more weekly meetings between owner, architect, engineers, and contractors should be scheduled.

b. Engineers

"The more subcontractors there are on a project, the more problems arise as each seeks to do his job more efficiently—even at the expense of others. For instance, the carpenter subcontractor building the forms does not try to make it easier for the reinforcing bar placing subcontractor to place the reinforcing bars and, in turn, the rebar contractor ignores the post-tensioning duct contractor (or electrical conduit), and all of that can be overrun by the concrete crew who are ready to place the concrete whether the rebars or ducts or conduit are in place or not."

"It is much better to have a specialist than a novice performing a critical operation. Professionals have no problem working together if the requirements are clear and there is a competent person coordinating the operation. The coordination effect is greater and the likelihood of incompatible details increases, but the contribution of this to failure is not significant."

"Certainly, communication problems are increased, but these can be overcome by selecting a competent design firms and then permitting them to exercise the necessary controls. With proper selection and contractual arrangements, there should be no need for increased structural failures."

"When employing a large number of specialty subcontractors, overall project management becomes very essential. Any breakdown in communication or coordination or interpretations when interfacing with each other can result in failure."

"More subs means more coordination required. Complex jobs are commonplace and should be organized for necessary control of the work."

"This is another 'mixed bag.' The answer to this question is yes and no since the use of more specialty contractors implies "fast-tracking," individual bidding of specialty trades as prime contractors and use

some form of management—CM, project management, project/constructions management, development management, et al. If the form of management is weak it will be ineffective and will contribute to failures. If the "manager" is strong, capable, experienced, efficient and understands the necessary management process, then the anwer is no."

"Obviously, project communications are more complex. It, therefore, puts an additional burden on the resident engineer to maintain quality control on the project. If the engineer has done his job well, there should not be any increase in structural failures."

"In most cases where failures have been thoroughly investigated and proved to be as result of designer error: a) comments were made by contractor (usually subs) and ignored; b) design or constructability issues were back passed or not considered by the 'experienced constructors.'"

"Specialty subcontractors usually improve the overall quality of the work."

"It can't if designers and prime contractor are not organized."

"It does not require more care by the engineer in verifying the interface between subs, but each of them is usually experienced in checking on what conditions exist that affect them."

c. Construction firms

"Depends to great extent how good drawings are."

"I don't care how many subs you have, make the general contractor responsible for the total job of construction, not design."

"You need a project contractor who can organize his job properly."

d. Construction managers

No response.

e. State and building code officials

"Coordination becomes a greater problem. Substitutions are sometimes made and approved when subs are unable to perform to maintain a schedule."

"The right hand has got to know what the left hand is doing. The more specialty subcontractors the more important the need for a well-organized communications network becomes necessary."

"The buck-passing can create many problems."

"Complexity of subcontractors demands stricter, tighter communications—not just for quality but economy as well."

"Certainly as the number of specialty subs increases so does the necessity for improved communications increases; without that communication on the project it would become chaos."

"Therefore greater need for professional designer/supervisor in charge."

"The state expects the general contractor and the architect to coordinate communications and verifies that they do."

"Increases complexity of job communications, but does not necessarily contribute to structural failures."

f. Owners

"In our work, we do not believe the number of subcontractors contributes to structural failures. The department's administration of a project from this standpoint is not changed due to who is doing the

function. Certainly this contributes to the communication and logistic aspects of the project and, in effect, makes the project more complex."

"When using a greater number of specialty subcontractors, the entire construction situation becomes more complex, the likelihood for any shortcoming increases. Especially matters such as forming, shoring, coordination between trades, etc."

"It is true that there is an increase in communication problems but does not necessarily contribute to structural failure."

"The Florida DOT does not recognize a subcontractor as anything but an agent or employee of the prime contractor so their prime is held responsible for the work of all his subcontractors. Under these circumstances, we do not feel that the involvement of subcontractors have any appreciable influence on the final product."

"With proper coordination and management, greater numbers of specialty subcontractors should not to contribute structural failures."

"Our bridge contracts identify specialty items that may be subcontracted, then a limit is put on the amount of additional work that may be subcontracted. The purpose of this limitation is to be sure that the general contractor has a major role in hands-on work, i.e., he is more than a broker."

"The prime contractor is responsible for coordinating the work effort of all subcontractors. The greater the number of subs, the greater part the prime takes. Our methods to review shop drawings and assure proper field techniques minimizes/eliminates any structural problems."

"When using greater numbers of specialty contractors it increases the complexity of project communications. However, this should not contribute to structural failure since the structural members are fabricated and installed in accordance with shop drawings approved by the structural engineer and are inspected at the site. So alterations to structural members are permitted prior to the structural engineer's review and approval. Problems could arise without such close checking of details."

"It does increase the complexity of communications. However, a competent organization will easily overcome this problem. It should have little to do with competent design or construction of structural details."

g. Developer

"Does not affect structure."

h. Banks and financial institutions

"More subcontractors on a given job tend to adversely affect communications and coordination. One sub may do something like drilling or cutting holes in a beam to make their work easier, not realizing it could be damaging the structural value of the beam."

i. Insurance companies

"We do not feel that an increased number of specialty contractors complicates a construction project. It does, however, increase the importance of coordination and communication."

"An increase in numbers increases communications problems; however, the specialty sub should be more proficient in his work."

"Complexity of project communications and structural failures not necessarily related."

"Reduces likelihood of failure if all subcontractors are appropriately monitored."

"Increases complexity but I don't know if it contributes to failures."

13. SUPPORT BY TESTING LABORATORIES

To what extent are testing laboratories responsible for notifying engineers of suspected defects?

a. Architects

"In our experience, testing laboratories have been totally responsible for notifying the design engineers of suspected defects. We have always recommended that the owner employ the independent testing laboratory rather than have him employed by the contractor so as to avoid any conflict of interest circumstance from arising."

"Don't know . . . but should be responsible to notify engineer even if it isn't state law."

"These people are professional people . . . and for them to withhold information of a suspected defect from an engineer is absolutely wrong! They cannot defend such an action and be called a professional!"

"Testing labs always submit test reports . . . that's their job. However, that's usually on field strengths of concrete and steel. For failure predictions, a structural engineer's opinion is the best."

"The specifications prepared by the design professional make it mandatory for all the test reports to be submitted to the office of the designer, to the owner, to the contractor for review. The test reports can be for foundation work, soil compaction, concrete, structural steel, etc."

"Our specifications (construction) list the types of concrete, steel, etc. testing required on the project. The laboratories are responsible for performance tests required, and submit reports of same to the engineer of record—or architect the labs respond only to testing requested by the A/E."

b. Engineers

"Depends on Scope of Testing Scores. Field tests of welded connections, for example, would be routinely reported to the engineer."

"This depends for whom these testing laboratories are working and what their contract reads."

"Major project labs notify architect who is supposed to notify engineer."

"The testing lab is hired to perform certain tests—the results are given to the engineer in typed reports. The reports should indicate any difference from standard and whether it is a deficiency or defect."

"It is not logically or ethically right to require a testing laboratory that is responsible for ensuring that the strength of the concrete is adequate to also report on 'suspected' lack of reinforcement (or improper placement). Hopefully, however, the communication between the laboratory inspector and the design engineer is such that the inspector would feel free to comment orally on 'suspected' defects."

"This should be made responsibility of resident inspection firm. Lab would report directly to this firm."

"OK if reports are timely."

"Testing laboratories will notify whomever *their clients* specifies. Notification should be made directly to the responsible engineer."

"During construction of hydroelectric projects, we normally maintain laboratories under direct supervision or control and monitor all results."

"We need a Federal statute requiring testing laboratories to notify the project engineers of all suspected defects in materials, fabrications, and construction."

"Properly drawn contract documents will provide the correct vehicle to overcome this type of problem and can clearly define the various responsibilities."

"Testing laboratories generally do not interpret the results unless specifically instructed to do so. They generally provide the data and the results for the design engineer or inspection agency to interpret. In this regard, they have not been helpful in preventing failures."

"Labs should note any deviation from normal, any deficiencies observed."

"Depends really on the terms of their contract. Again, past performance is a good criteria for selection of a testing laboratory. An engineer can contract for the responsibilities; he has learned from experience that the laboratory is capable of carrying."

"Testing laboratories should be agents of client or his engineer should be required to call defects to their attention promptly."

"Testing agencies—as members of the 'team,' are always responsible for reporting what they see (as professionals). But they are sometimes reluctant to take on 'undue responsibility.' "

"Testing laboratories should always be responsible for notifying the designers of defects they may detect. I reiterate, to be effective, they must be responsible to the owner and design them, not the contractor."

"Contract documents should require engineer to be notified of any suspected defects."

"In Washington State, many labs do not even have a registered engineer and yet they are certifying the adequacy of construction. This is an area that certainly needs attention."

"In our specifications we require that one copy of all tests be sent directly to us. That way no one can bury bad tests and we can keep track of them for quality and quantity conformance to specs. Again, the engineer must set up his contract documents to get what he needs."

c. Construction firms

"In this question, we're assuming that the testing laboratory has been employed by someone other than the design engineer. I feel it is the responsibility of whoever employed the testing laboratory to report the results of any tests showing any suspected defect to all the parties involved who may have a responsibility for the project."

"Depends on contractual agreement."

"Really weak part of entire process."

"Architect should specify items to be tested and reports should be made available to him and contractor."

"They at least have a moral obligation."

"It depends on the scope of the work contracted to the testing laboratory. The interpretation of the results should be the responsibility of the designer."

d. Construction manager

"Great extent."

e. State and building code officials

"Our contract as the owner is with the testing laboratory and we require them to notify the engineer as well as us."

"This is an extremely gray area. It is suggested that NVLAPN (National Voluntary Laboratory Accreditation Program) be contacted to obtain an insight regarding this issue. It is maintained that there will come a time when there will be/should be a national laboratory accreditation program."

"Contract with testing laboratories should require their notifying engineer."

"Testing labs public volumes which indicate how specific products responded to their testing methods. Structural engineers probably subscribe to these manuals/publications."

"Depends on the integrity of the testing laboratory. Any reputable testing lab would notify an engineer of a suspected defect if the lab had been employed to test products or materials for the engineer."

"Outside California, I think history indicates the seismic loading requirements appear to be adequate in the uniform building code and I assume the other two major building codes are similar. The structural design engineer needs to research earthquake history and probability for any given building in a specific location."

"Testing labs are for use of the professional as needed."

"On state projects in Nevada, the testing laboratory is responsible for notifying the architect and the state of suspected defects. Re-tests are common."

"Dependent upon contractual agreement."

"The contract the testing lab has with the owner or engineer should state the responsibility of the lab to those involved."

"Varies with each project."

f. Owners

"Limited in scope."

"In the Veterans' Administration, the testing laboratory is required to notify the Resident Engineer of suspected defects."

"In our work, all testing is part of the project and all test reports are made a part of the project records. All defective, or suspect material, is fully examined or retested and only specification material is incorporated in the project."

"Testing labs have a moral and professional duty to inform engineers of suspected defects."

"Testing labs should issue a report on all materials submitted for testing as to whether they are accepted or rejected. This report should be reviewed by an engineer."

"Contract requirement to report all deficiencies."

"Depends on the owner/contractor agreement and the chain of command and line of communications established for each job. State laws vary. Use of a testing lab is usually at the discretion of the owner for private work and may or may not be required by agencies of government. Often, the use of a testing lab depends on how successful the architect/engineer is in getting the owner to pay for that service."

"Usually dependent upon who retains the testing laboratory."

"This is also dependent upon the provisions of the contract, and whether or not the owner or the structural engineer has hired a testing laboratory."

"Testing laboratories are fully responsible for notifying the construction engineer of any suspected defects."

"Should be required."

"It is not clear who the laboratory client is assumed to be in this case. In any event, laboratory tests should be reported accurately and objectively. At Caltrans, most quality assurance testing is done by the department's own laboratory. Other work such as weld inspection by radiograph is provided by a licensed testing agency at the contractor's expense."

"Only for those items which the contract requires testing by a testing laboratory. For structural concrete, items such as aggregate, cement, reinforcing steel, and compressive strength tests are required to be tested and certified by a testing laboratory. For structural steel, these items normally include bolts, welding electrodes, structural steel members and in-place testing of connections."

"The authority has its own M.I. inspection department. They inspect the structural material and fabricated members for each project. If defects are found, the materials or improperly fabricated members are rejected."

"Purdue uses testing labs for all structural elements. This should be a part of the design specifications."

g. Developers

"Testing labs should be more responsible to engineer and city or county or state—Federal building inspection department."

"Depends on contract."

h. Banks and financial institutions

"In-house project manager is responsible for programming, monitoring, and distribution of test results. Most usually the developer or building owner will contract for the testing required by codes or by engineers in specifications. This will usually eliminate cover-up between building contractor and a friendly testing lab."

"Testing labs are hired by the engineers at the owner's discretion . . . and only check specific things, not the whole job."

"Testing laboratories are responsible for notifying structural engineers of suspected defects to the extent that they do or are required to check."

i. Insurance companies

"Our experience with testing laboratories are that they report the condition which is found in performing field tests and materials tests; it is normally the responsibility of the architect and/or engineers to determine if conditions and materials are within the allowable tolerance."

"In some cities these laboratories are poor—obtain work on lowest bid—cannot afford to pay good personnel because of low bid situations."

"All Aetna projects employ testing services."

"Depends on how specs are written or terms of contracts."

"Responsible only for those items he is hired to check."

"If it is a reliable testing laboratory as accepted by most state codes, there should be no problems."

"We require testing of all materials (concrete, plumbing, electrical, steel, connections, etc.) by independent consultants on all projects."

"As a matter of practicality most testing laboratories inform design engineer of failures they are aware of."

"Should be to great extent."

"Why wouldn't a testing laboratory notify engineers of suspected defects? They are bound by professional ethics in the same way as other design professionals."

14. CERTIFICATION OF BUILDING, YES OR NO?

Should public buildings be certified and could this reduce the probability of structural failures?

a. Architects

"In response to a question on building certification we received, there is a general lack of understanding on the part of the public as to how the building design and construction industry differs from other industries such as the aircraft or automobile industry. In the aircraft or automobile industry, for example, a prototype model of their design is made and subjected to exhaustive testing. On the basis of this testing, designs are refined, installed in the prototype, retested, further refined, and retested until the desired result is achieved. Once this point is reached, all components are mass-produced in like kind in thousands of multiple copies and picked up by the user. Yet in my experience, I have never bought an automobile on which everything was perfect and did not require some adjustments. In contrast, building designers have one shot at putting on paper in two dimensions the design for a three dimensional structure with more parts, pieces, and systems than exist in any automobile and most airplanes. In this case, the prototype is the end product and absolute perfection in the design or construction is by virtue of human involvement, impossible. It is possible, however, given sufficient time and funding, to achieve adequacy and avoid catastrophic failures through the process which now exists."

"Why look for controls? Why not tackle the causes that contribute to failures? Controls or other similar measures, such as certification, do not correct the problem, rather add cost and generally more red tape. Value received compared to money spent should be given high priority."

"Insurance companies, like A/E firms, are only as good as the personnel they employ to certify or inspect. Our experience has been that some IC employees like others are *not* qualified to certify. A registered A/E with many years of experience is required. How can one person be qualified for not only structural, but mechanical, (HVCC) electrical systems?"

b. Engineer

"I think that certification leading to lower insurance premiums could lead to some positive things in new buildings, particularly relative to Life Cycle Costs, BEPS, and others. Structural elements could benefit

but I question whether thhey would lead in the list of benefits to be received."

"The solution to any problem that exists, if any does, is in enhancing the position of the professional depended on to design an appropriate structure; provide the proper work environment."

"This could help."

"Areas or buildings are usually certified as to general capacity or occupancy."

"Building plans are not 'certified' by the structural engineer when he places his seal on them. Certain municipalities like Chicago also require a certification by the engineer or architect 'that the building was constructed in general compliance with the plans' before an occupancy permit is issued. What further form certification could take, we have not thought about."

"Certification only places primary responsibility for failure and does not provide an answer to structural failures. Structural failures can only be prevented if the structure is adequately designed, and constructed, with no changes unless approved by the structural engineer."

"Certifications should not relieve a builder of this liability."

"Again, a certification program could create more problems than it might solve. It must be remembered that total perfection cannot be guaranteed, only what a reasonable and product design professional may be expected to provide for quality control."

"Public buildings are in general designed for a specific use and they should be certified for that particular use only. A detailed investigation and structural analysis should be performed whenever use and occupancy are changed to ensure adequacy of design."

"Design and inspection by properly qualified staff are most important. Certification of a building is not enough in itself."

"Certification could be useful but question is—by whom?"

"Changes in occupancy are commonly a problem. An abandoned school has spaces suitable for warehousing or industrial tenants but the floor loading is inadequate. Building bureaus could be required to certify acceptable uses or loads to a prospective buyer before transfer of deed can be registered."

"Insurance companies are generally more concerned with fire protection than structural soundness."

"The most effective way of averting failures has been: a) design check by peer professionals; b) thorough Q.C. in field. Certification could mean that a worthless paper is signed unless done by an independent engineer."

"Certification is a useless exercise as far as reducing failures is concerned. When the architect and engineer apply their seal to the drawings that should be enough verification of design adequacy."

"Before the use of a building is changed, it should be checked by a structural engineer."

"Certification of public buildings could reduce the probability of structural failures. However, we believe it neither necessary nor economically prudent."

"The idea of certification is frought with so many liabilities that construction costs would rise dramatically if the designers, insurance companies, or anyone else had to make a certification."

"Any owner who invites the public to use his premises should be financially responsible for whatever happens. Insurance is the logical means for doing this. Therefore, the insurance company should be able to rate a building for risk and set a premium accordingly. It might even help make good construction profitable."

c. Construction firms

"Aircraft and buildings are two different items. Do not feel reasonable other than state licensing was to certify buildings."

"This is dumb. If the design firm does its job and the contractor does his, the building will be built right. To get another outfit involved would make it more expensive and not accomplish anything."

"All buildings could be certified but at what cost? Who would certify the certifiers? And what liabilities would the certifier incur by certifying?"

"The licensed design engineer in most cases is the one person who certified the structural integrity."

"Simply improve the quality of drawings and specs and the quality of on-site inspection."

"Who certifies? This would be a mess. Design professionals should be responsible for acceptability."

d. Construction managers

"Structural failures cannot be reduced by certifying buildings. Professional engineering quality must be certified and construction quality should be recognized. Certification of structural engineers could be accomplished with registration by examination on a national scale as the states of Illinois, Washington, and California now practice. This practice coupled with the requirement for certified inspectors furnished by the owner or client as is practiced in California would for institutional, government, and industrial projects above a minimum cost provide excellent certification of the design."

e. State and building code officials

"No. This would, in my opinion, be a very complex and costly procedure as well as time-consuming."

"With full-time inspectors, now, a building has a certification but perhaps a registered professional should be that inspector."

"Some states have a certification program, others do not. However, the degree and extent of effectiveness varies significantly."

"Many times local situations can vary the degree of compliance. Perhaps an independent certification would reduce the problem."

"All public buildings should be under state enforcement jurisdiction for code plan reviews and inspections."

"Why should an insurance company assume the liabilities of an architect, structural engineer, or building official?"

"Public buildings are certified now, i.e. the engineer certifies his design will adequately carry the *design* loads when he affixes his seal to the prints and the calculations. The building official certifies the building meets the code and is safe to occupy (as long as design loads are not exceeded) when he issues a certificate of occupancy."

"The professional designer, architect or engineer needs to be responsible and file a completion statement."

"Under the UBC, buildings are designed based on their proposed use, occupancy and type of construction."

"Builders need not be certified."

"Many states use the private insurance companies to inspect and certify boilers and pressure vessels. Same could be used for building inspections."

"Probably not."

"Why only public structures? Competent qualified engineers retained by the insurance companies and the leading institutions should do the certification of the structure from the design phase through the occupancy stage."

"If the safeguards that are not in the system work, adding another process to go through is not necessary. Design should follow codes. Plans should be sealed by engineer/architect, approved by municipal authority having jurisdiction and constructed according to plans."

"Utilization of established building codes for design and specification and close adherence to the design during construction would be in itself a form of certification. Experimental design, etc., should be tested as a prototype and certified before wide usage."

"There is the state agency with the authority or expertise required for such certification."

f. Owners

"Certification may be helpful if properly enforced."

"Present regulations are sufficient."

"The West Virginia Department of Highways feels that we do certify a structure when we accept it from the contractor. We are assured that at that time the structure was constructed in accordance with the plans and specifications."

"Buildings should not be certified. This will only build-up a bureaucracy and impose more regulations on the industry. The risks do not justify an overkill approach."

"Certification would be effective only if the owner is willing to pay for the proper quality control needed to assure compliance with all necessary design and construction features. Certification should only be mandatory for essential facilities, such as hospitals, communication centers, large auditoriums, schools, etc."

"No! Certification may work for airplanes when the FAA (and not the private sector) has billions of dollars and thousands of employees for the job. So long as private sector architects and engineers are licensed and presumed competent, there will always be the need to depend upon their judgment as the best means of assuring safety. Substituting 'certification' as a magic panacea instead of simply requiring best judgment, as free from error as human judgment will alow, is simply not within the tolerance levels of the existing systems. To 'certify' a building and thereby imply absolute safety and absence of any potential danger whatsoever is deceptive and not humanly possible. Maybe NASA should be required to 'certify' that every aspect of the space program will be successful (who would sign the certificate?) and maybe if architects and engineers could work with a budget comparable to that for NASA there would be no mistakes. Where professional skills are concerned, certification is a legal expedient only, and in and of itself adds no additional protection. Ask

the insurance companies who provide professional liability insurance for design professionals what they think about certification."

"Not considered necessary. Present system considered to be adequate. Insurance companies would have to hire the expertise required, which would tend to increase premiums, rather than to reduce them."

"Individual design."

"Occupancy permits given by the local building departments specify and control the particular uses of the structures for which they were designed."

"A method of recognizing construction quality in insurance premiums might motivate the owner to improve quality. However, the ability of insurance company engineers to assess vulnerability of a building to failure with a nominal effort is questionable. Professional liability insurance rates must already reflect a firm's track record."

"There should be no certification required. It is felt that this would create additional paperwork thus taking away from available design funds."

"In essence, when a Naval facility is constructed, it is certified by the professional engineering staff. Likewise, if a public building was designed and constructed by professionals, additional certification should be unnecessary."

"Achieving fail-safe structures would still be limited by the competency of the inspector/certifier."

g. Developer

"This is difficult—who would certify? The architect/engineer/builder/developer. All would want to limit their liability and try to shift blame on others."

h. Banks and financial institutions

"Obtain certification of occupancy."

"Good quality control by qualified inspectors should be adequate."

"All this would do would shift the responsibility to another engineer who would then need to review all design criteria before certification could be given. This would increase costs because of delay in design review."

"Buildings are certified for specific use now, under the certificate of occupancy."

"I don't see a feasible method for this type of certification."

i. Insurance companies

"We do not feel a certification of buildings would be of any great value in reducing the possibility of structural failure. We are of the opinion, however, that there should be a requirement to post the design floor loading on each floor of every building, and an appropriate location that would permit preserving this figure at all times."

"Not sure—with so many experts already looking at the progress all the way through, how would one more stamp of approval gain anything?"

"Properly engineered and built—meeting state-of-the-art—this should suffice."

"Begs the question of who will check the checker."

"Certification of structural and life safety aspects during construction is a possibility, should be by licensed engineers, not building departments."

"No. The certification processes employed by most lenders today are adequate."

"Stiffer codes and stricter enforcement might be a better solution."

"No. Responsibility should still be with the licensed professionals who design the building. Aircraft certification is for a manufactured product, and is not applicable to buildings. If a procedure of building certification were to evolve, it would just increase the cost, increase government intervention into private economy and all without any appreciable safety increase."

"No. And I doubt it."

"However, costs to builders, owners, of servicing such an amount would be extremely high!"

"Keep the government out of the approval/certification process. It's too costly and time-consuming. Structural engineers should certify—they are most intimate with the project."

15. THE ROLE OF LENDING INSTITUTIONS IN PROMOTING SAFER STRUCTURES

To what extent can lending institutions and insurance firms contribute to enhanced safety of structures?

a. Architects

"Not so much zero failures but owners and developers who show and demonstrate an interest in safety, have a formal safety and quality program, and can show how they will enhance quality of construction by their involvement in the project."

"A/E liability insurance companies follow both these practices."

"They should encourage owners to obtain 'certified' as-built buildings."

"Professionals (architects and/or engineers) who are qualified must be registered. This then would satisfy the suggestion of approvals. The emphasis should be placed on more quality control and proper communication between the designer and the contractor. Pride and integrity of all parties in the proper execution of their work is the key above all other considerations."

b. Engineers

"Join in an effort to achieve the proper 'work environment' for the profession. This includes:

1. Fees;
2. Freedom to perform in a professional manner;
3. Selection based on qualification and experience."

"They should take a more active role and insist on quality and safety."

"If insurance companies would write policies for each project that would cover all professional designers for all suits, it would lessen the reluctance of the professionals to be more active in participation in the construction phase. Such insurance would not prevent the insurance company from suing any designer who was negligent under a strict interpretation of 'errors and omissions.' Each professional would therefore still carry his own 'errors and omissions' policy. Obviously if this were normal practice, insurance companies would restrict their coverage only to 'approved' architects and engineers."

"In addition they can sponsor seminars on past failures and the methods used for corrections."

"Insurance firms already adjust their premiums depending on the past record of the client."

"Certainly, lending institutions will not have the 'background' to establish fees or approve designer qualifications. Should they be forced to create staffs capable of this responsibility, it could only increase their operating costs and ultimately interest costs. Insurance firms providing errors and omissions coverage have programs designed to enhance quality and reduce claims."

"The lending institutions should engage qualified architects and engineers to design the structure. Qualified and experienced consultants can produce quality design and monitor construction to eliminate chances of structural failures."

"Require design by licensed structural engineers experienced in public structures. Fees should be high enough to cover an independent review of design."

"All listed options would be helpful. Insurance companies should be more concerned with the competence and conscience of the firms they cover than with their size and annual volume."

1. Insist on use of competent engineers for design.
2. Insist on construction by designers.
3. Insist on appropriate periodic maintenance inspections.
4. Insist on prompt correction of defects."

"Approval of: Design professionals; developers; construction managers; and contractors."

"Most lending institutions require independent review of design documents which provides a good quality control measure."

"We do not believe that there should be any preferential treatment where safety of structures is concerned. The safety of structure should always be first and foremost."

"They should evaluate risks according to the kind of structure and people involved, and charge accordingly. Everyone wants to forget the bad things that might happen and collect the going rate now. If they were more careful in their lending practices it would help. But banks have taken over the pawn brokering and insurance companies have their rates largely set by the states."

c. Construction firms

"I feel that lending institutions and insurance companies could be a vehicle for training field personnel. Since it is the experience of their claims which could be a source for information on how to overcome the problems encountered, they could use this information by transmitting it in the form of instructions to field personnel."

"Little—not their area of expertise."

"Should not be involved."

"Maybe."

"They shouldn't—can this be done by a registered engineer or architect and again make them responsible with a bond or something similar."

"None—they stick to lending and insuring."

"None. They must insist on quality workmanship for the designer and worker in field which is *responsible* management."

d. Construction managers

"Insist on higher fees for engineers, high quality professional engineering should be reimbursed."

e. State and building code officials

"I don't believe this is a proper place for their involvement."

"Sometimes it is easier to obtain compliance when financial rewards are offered. So many times we see contractors trying to comply with standards, loose bids to contractors, who for one reason or another do not comply with applicable standards, because naturally they bid cheaper."

"Insurance companies and lending institutions could certify design professionals. Insurance companies could charge higher premiums for code-deviant buildings. Lending institutions could make payments in the wake of inspections."

"All of these are incentives to achieve greater safety."

"Not appropriate actors at all."

"Many times premium payments are the main concern of the insurance companies. This is an underwriter's problem."

f. Owners

"Get selective as to qualification of engineer and architects."

"If insurance rates on suspect structures are increased to such degree that insurance is not cost-effective, then owners will, on future structures, so construct that their insurance rates are competitive. Certainly more emphasis on quality than claim is valid."

"Low interest rates or premiums to parties based on experience and success record. Training, idea sharing amongst clients."

"Lending institutions currently show little concern for the professional qualifications of designers. Much design is performed by unlicensed individuals. A focus on the quality (i.e. safety) of a facility, as well as on its commercial value, might tend to lead developers toward better design. As a condition of minimizing insurance premiums, insurance companies might participate in the selection of design professionals."

"It seems reasonable that a lending institution or insurance company should have a chance to concur in the selection of architects and engineers."

"Conduct periodic building inspections during the construction process by qualified professionals."

"Lending institutions should stay away from quality evaluations."

"Make sure the client is using an experienced, qualified architectural/engineering firm for design and that a good construction inspection program is followed."

g. Developer

No responses.

h. Banks and financial institutions

"Lending institutions and insurance firms don't have the capability to contribute in this area. It is up to owners to make sure quality of design and construction is obtained. Unfortunately, current tax laws penalize the owner by taxing the building based upon its value or cost."

i. Insurance companies

"Too often, in fact in most cases, the lending institutions and the insurance firm has no knowledge of a project being planned until such time as they are approached for funding or for insurance coverage. This leaves the lending institution and the insurance firm with the option of turning the project down or making their own cursory exam of plans and specifications and/or relying on the reputation of the architects and engineers involved."

"Don't know—our projects are generally (almost always) internally funded."

"Tighter financial controls would, in my opinion, extend better control overall."

"Attempt to assure that developers do not short circuit proper design and construction quality controls."

"Lending institutions can institute a policy of involvement only in those structures of high quality. The financial consequences would have to be evaluated and methods worked out to allow high quality construction without restricting an investment program to a point where it is discriminatory."

"Lending institutions require independent verification of quality of engineer and compliance. Insurance firm—same."

16. ADEQUACY OF SEISMIC CODES IN AREAS OUTSIDE OF CALIFORNIA

How effective are current building codes (outside California) in assuring that structures are designed and built to withstand probable seismic acceleration forces? What additional requirements, if any, should be required?

(California was specifically omitted because it is believed that their seismic codes are among the best.)

a. Architects

"Codes should have three categories: (1) high seismic probability areas—seismic analysis required; (2) low seismic probability areas—no seismic analysis required; and (3) intermediate seismic probability areas—up to engineering, depending on life of structure and use. Code should have map to show all three areas."

"Most codes do identify sections of the country where seismic conditions have an affect on design. With this input, it is up to the design professional to investigate and determine whether the controlling element is seismic or wind."

"Each project depends on location—each one should be separately analyzed by a competent engineer."

b. Engineers

"The need for seismic analysis in other areas of the country is now undergoing extensive review by several professional and governmental groups. The question of 'what is responsible risk' must eventually be answered. We don't design buildings for direct tornado hits, for example."

"In some instances they may be too restrictive. However, generally they are effective."

"Codes should require consideration of seismic effects in regions subject to a significant probability of earthquake. However, generally they are effective."

"Codes should require consideration of seismic effects in regions subject to a significant probability of earthquake. The manner in which structures are designed for earthquake-resistance should depend on the engineering; a separate seismic analysis is not usually necessary."

"Most qualified engineers will design for seismic forces."

"Responsible engineers should be aware of seismic potential and design accordingly. Codes should be updated to provide adequate guidelines to assist the engineering."

"Seismic analysis is not unusual at the moment, but essentially restricted to areas of high seismic activity (nuclear plants are an obvious exception). Seismic analysis in areas of low activity would probably do nothing but increase costs with no appreciable return for expenditures."

"In the recognized and established earthquake zones, the existing codes are quite adequate to produce earthquake-resistant design. However, in certain sensitive areas and for sensitive projects, an independent seismic analysis should be performed by a consultant experienced with earthquake-resistant design."

"Codes are generally adequate. Design standards are common in earthquake areas. Each state should determine its needs and differences for locations within the state. Other than UBC, only fair."

"This of course depends on geographic locale, funding, etc. We find codes (with amendments) are fairly up-to-date, on the other hand, we have seen some inadequate, antiquated, irrelevant codes requiring a complete redo."

"Obviously most fail to provide for seismic events unless that area has had an earthquake. Even in San Francisco it took over ten years from the date of enacted legislation (Field Act) to effect a program of correcting structural deficiencies related to seismic conditions in San Francisco schools."

"AASHTO considering updated seismic specifications. Outside California, Alaska and a few other highly active seismic zones, present specifications seem adequate (can one point to a seismic failure of a bridge in any other area?). P.S. Note we are bridge engineers."

"In Massachusetts the seismic issue has been dealt with relatively well. Other states have ignored the issue. Some places it's simply not appropriate!"

"It is difficult for codes to adequately address seismic design because the state-of-the-art is continually changing. Designers who work in high seismic risk areas should be required to continually educate themselves in order to maintain their competence."

"Most codes are adequate in assuring that structures are designed and built to withstand expected seismic forces."

"Reasonably effective. It should be understood that seismic design is 'state-of-the-art' and undergoes changes periodically."

"A few years ago a consulting engineer remarked to me that we in Connecticut were lucky not to have to be bothered with seismic loads. He did not know it was in the state code. In Massachusetts the provisions are regularly ignored and they have an excellent code. Building codes are ineffective and so is licensing."

c. Construction firms

"The structural engineer or architect should have to certify to the coded enforcement agency that the building has been designed for the appropriate seismic zone for which the building is located."

"No knowledge."

"Probably OK—how many failures?"

"It depends on the seismic history of area."

d. Construction managers

"Building codes provide guidelines for seismic design requirements but codes only identify minimum requirements; the engineer must use judgment to determine the degree and probabilities for seismic requirements, based on reasonable costs to the owner."

"Generally effective."

e. State and building code officials

"Our area is a low risk area and I believe the State Building Code for Minnesota is adequate."

"Only if building is located in earthquake zone 3, 4, or 5."

"Major work is being done to bring seismic events into the manifold of specific building code criteria by BSSC (Building Seismic Safety Council). Therefore, it is suggested that BSSC be contacted to share their knowledge and research regarding seismic events and standards criteria."

"The code is effective if the work is designed by a licensed designer."

"Current codes are adequate for Idaho seismic forces."

"The three model codes require seismic design is required areas."

"Code development regarding seismic activity is not a political priority in Oregon where we have a state building code. Responsibility now is in the hands of the architect or design professional."

"Seismic considerations must be evaluated when necessary. For most structures in Wisconsin, no special design considerations are needed."

"Nevada parallels California requirements. Codes could be improved with more basic research in seismic design."

"Effective in N.E."

"Many states, when adopting a building code, delete the seismic articles and sections."

"Florida not normally subject to seismic acceleration forces."

"In some areas even a minimum seismic design would not be cost-effective. In other areas even a minimum would be an improvement over their current practice."

"In health facilities seismic consideration is a requirement."

"The state adopted UBC, Chapter 2312, Sets Seismic Design Parameters."

"This would have to be a judgement of the consultant based on the building location."

f. Owners

"Consideration should be included in design based on zone of seismic area."

"Building codes are a minimum requirement and should not take the place of sound engineering judgement."

"In West Virginia, we have no difficulty in observing the seismic aspects of the AASHTO specifications. We feel they are adequate."

"Effective to our knowledge."

"Possibly one mandatory building code which would address this requirement."

"Seismic acceleration forces are not required in the Washington Metropolitan area. However, wind load analyses of structures are required by local building codes. The Washington Metropolitan Area Transit Authority design criteria also emphasize those requirements."

"I am not familiar with requirements of states other than California. Studies by the Applied Technology Council (research unit of the Structural Engineers Association of California) have developed suitable seismic codes for buildings (ATC 3) and bridges (ATC 6). A proposal to adopt the provisions of ATC 6 as an AASHTO guide specification will be voted on in October."

"Again, building codes are very effective if adopted by the municipality."

"Considering the small percentage of failures, they are apparently effective."

"The Navy seismic codes are very effective and current with regards to structural requirements."

"Codes are generally adequate."

g. Developers

No responses.

h. Banks and financial institutions

"Should be based on seismic area rating."

"People as a whole would rather copy these codes of California than investigate their immediate seismic activity."

i. Insurance companies

"Our experience has been that current building codes are reasonably up-to-date and if complied with will result in structures of suitable design to withstand conditions which are anticipated in the areas to which they apply. Special conditions should apply to coastal areas as well as to areas subject to seismic conditions to compensate for hurricanes and earthquakes."

"The engineer should be well versed in the need for special design depending on the area involved."

"This will vary from place to place."

17. IMPACT ON SAFETY OF STRUCTURES AS A RESULT OF USING THE CONSTRUCTION MANAGER TYPE ORGANIZATION

Does the role of a construction manager versus a general contractor impact the probability of a structural failure? How?

a. Architects

"In some instances, construction managers tend to isolate the designer from the builder and take liberties in the substitution of materials in the interest of cost savings alone."

"Never on fee. However, owners should be made aware of customary fees and services to expect for a given fee. We need to inform the public."

"The government should take the *lead* in this . . . instead of asking for *price proposals* for engineering work . . . you certainly don't do

this for medical work, and *their* responsibility is no greater than ours!"

"Independent and competent managers' overall supervision improves quality."

"The selection of the professional, whether it be the architect and/or engineer, should be based on satisfactory past performance. Upon verification, a fee proposal should be asked from the professional and compensation for services negotiated. Competitive bidding and using the low bid as the basis of selecting the professional is unwise. The design prepared by the low bidder can only add costs to the project and lead to unfortunate experiences."

"A construction manager, in the interest of completing the project on time, may pressure the contractor to speed up construction at the expense of quality. This, however, would be on rare occasions and would not be a likely contributing factor to the problem of failures."

b. Engineers

"Again, the factors of experience and methods are the dominate consideration; not one process versus the other. There is no reason why construction management processes should not be competent or superior, particularly if the CM is by the same firm who performed the design."

"Generally this situation disperses responsibility and makes supervision more difficult. Hence, probability of structural failure is greater."

"A number of different items could enter into this. Contractor builds by plans—manager also goes by same plans, but if in doubt should refer back to design group."

"Has less control over construction."

"The construction manager, by representing the 'true' needs of the owner for a quality structure and not by just being a 'watch dog' of the owner's pocketbooks, can greatly lessen the probability of structural failures. Construction managers primarily concerned about costs and time greatly increase the probability. The construction manager by virtue of his role as the owner's representative should be in a better position than a general contractor."

"Most construction managers tend to over-assert themselves and their authority and sometimes make unqualified structural changes without consultation with the structural engineer. Most contractors are afraid of CM and sometimes will build structures which they may feel are not up to par simply because the CM pressures him."

"While not all contracts work the same, normally, the success of the general contractor depends on turning low bids into profits. The construction manager has no profit incentive other than his professional responsibility to supply the best product at the lowest cost to the owner of the structure."

"The selection process provided by the Brooks Act is undoubtedly the best for all involved, no matter if the public or private sector is involved in the selection. Basically, this provides for selection on the basis of competence, followed by negotiation of a fair and equitable fee. Competition is provided for, not only on the basis of competence, but also on past experience, past performance, the ability to provide immediate service, etc. The negotiation provides for proper matching

of scope of work and fee. The process does demand that an owner 'do its homework' since the simplicity of a low bid approach is not present. This, too, is a benefit for it contributes to a good working relationship and the development of trust between the parties, considerations that are all important to a successful project."

"Though it depends largely on the individual managing the project, other factors also impact on the probability. Experience, team effort and track record also play a major role."

"CM in some cases works to detriment. Particularly where CM is different than design engineer."

"The structure of the question immediately signals a serious problem. Note the questions for the selection of architects is different than the questions for engineers. Why? Because the latest (not always in the past or even the present) means of employing engineers is through the architect. The selection process is:

1. Invite competent, relevant professionals (architect or engineers) based on experience and past performance (care should be taken not to evaluate new professionals)—A good RFP would accomplish this.
2. Select on basis of response to TFP and presentations made, grade as to No. 1, No. 2, et al.
3. Request a detailed proposal with work plan, staffing plan and fee basis.
4. Negotiate fee (do not be hampered by inappropriate or faulty budgets). If fee cannot be negotiated go to No. 2 selection and so on."

"In my opinion construction managers are appropriate on only complex projects. *But* for specific details, and averting them, they may become a bureaucratic impediment unless they defer to some specific engineering expertise which they seldom do."

"In every instance, designers should be selected based on experience and qualifications without regard for price. *After* selection the fee should be negotiated. If negotiations are unsuccessful, then another qualified designer should be selected and the negotiation process resumed. In *absolutely no case* should designers be selected on a low bid basis."

"We believe, although design cost is one of the factors in selecting an architect or engineer, it should not be the deciding factor. Initial or first round selection should be based on the experience and previous performance of the interested architects and/or engineers."

"The whole subject relates to the proper selection of the building constructor or manager."

"Selection should be based on a variety of criteria including those listed below except for competitive bidding. Competitive bidding results in the lowest design cost but often the most expensive building costs. Since the building costs more than the design, there is no savings in the bidding of professional services. Unfortunately, most governmental agencies look upon this as an attempt by the professionals to protect their 'turf'."

"Bidding only obtains the low price and typically a service of similar value. Negotiation is necessary, but services are the element generally neglected. It is always easy to cut back the services for a dollar savings."

"Competence should be the main factor in the selection and the best guides are education, experience and reputation. Those making the selection are seldom knowledgeable in architecture or engineering."

"Construction managers tend to assume a role of supremacy that they do not deserve. They want any short cut to save money and time and they are apt to be made closer to the owner than the engineer is. My experience has been that we must argue and prove our point at every turn. It is worth a 20 to 25% fee increase if a construction manager is used."

c. Construction firms

"No, most general contractors do little of the on-site work with their own forces (building work)."

"Not if he does his job."

"It may depend on scope of services to be provided under CM. Whatever the situation it *always* depends on the individual connected with the project."

d. Construction manager

"A good CM will coordinate structural engineering with overall concept of building."

e. State and building code officials

"The general contractor has more at stake on a construction than a construction manager. He therefore may be more responsible for quality and performance of a structure than a construction manager."

"State law prohibits competitive bidding. Board procedures give preference to qualifications and experience."

"Tends to dilute responsibility unless clearly spelled out in the architect and construction manager's contract."

"Competitive bid should not be used. Experience and past performance are very good measuring tools to consider."

"Architectural firms and construction management firms should *not* be affiliated. Too often potential conflicts-of-interest occur and could cloud proper direction."

"Many intangibles play a significant role in this area. One could have a well-qualified construction manager but a poor contractor or vice versa or both good or both bad."

f. Owners

"Depends on the personnel."

"We could certainly hope that this is not a possibility. The role of a construction manager is assuring the structure is constructed in accordance with the plans and specifications. This should produce a safe structure, assuming the plans are correct."

"The construction manager usually has higher professional qualifications than a general contractor and thus is more likely to be alert to possible problems and to have experienced structural inspectors on the job."

"Construction manager's focus on cost reduction might lead to the taking of risks."

"A construction manager, as a representative of the owner, has more incentive than a contractor or builder to control quality and thereby minimize the probability of structural failure."

g. Developer

"The general contractor really is the key along with his job captain or job superintendent."

h. Banks and financial institutions

"They are essentially one and the same."

i. Insurance companies

"We see no need whatsoever for the construction manager approach to building construction. It seems that this approach merely imposes an additional party which only increases the cost of the project in a timely and economic manner. This position, of course, is taken on the assumption that the work is being performed by a qualified general contractor who has in his employment capable and qualified subcontractors."

"Our projects (most relevant ones) are all constructed using CM approach. We believe this results in a closer identification of the CM with the owner than the General Contractor approach; therefore, the CM look out for the owner, improving probability of sound structure."

"Construction management reduces somewhat the probability of structural failure—more interactions within the building team."

18. IMPACT OF FAST-TRACK SCHEDULING ON STRUCTURAL SAFETY

What influence, if any, does "fast-track" scheduling have on structural failures?

a. Architects

"Fast-tracking" projects, where early structural contracts are let before other design disciplines are complete . . . save time . . . have an impact on the project. Again, this requires the structural engineer be strong enough . . . and experienced enough . . . to know when a project can be released for structural construction. This 'fast-tracking' process must understand that errors will occur . . . and these must be rectified by design changes when they occur . . . it requires good field supervision and good field/designer coordination."

"Fast-track does not and should not affect quality of design of various components of a project. It is merely a tool to expedite a project. The prime concern and emphasis in fast-tracking a project should be in maintaining good communication among all parties involved."

b. Engineers

"I believe that we should be able to fast-track construction successfully if done by firms with adequate experience and advanced methods."

"Fast-track properly done should have no impact on structural failures, but normally fast-tracking is conducted in such a way that each subcontractor is pushed to the limit to perform his work too fast or too soon. Consequently proper inspection is difficult if not impossible."

"Obviously, it is easier and less costly to make changes on paper than to change items already constructed. Since fast-tracking is cost-effective, it should not be abandoned, but rather there must be adequate design review and quality control."

"Fast-track comments are basically the same as for construction management. To be effective, it requires an experienced design firm with commensurate authority through the life of the project."

"Fast-track jobs demand tighter control, team effort and excellent management and communication. If these elements are present, chances of occurring failure are minimal. However, any changes made during the progress of the work must be thoroughly investigated for their impact on structural integrity."

"Proper safeguards in structural review should allow fast-track construction procedures."

"Answer herein given responds to existing practice. Most of the projects claiming to utilize fast-tracking are not, in fact, doing so. All that is being done is to rearrange the design sequence, not a true scheduling of project requirements or development of action initiating relevant project information by all to eliminate subsequent design changes and potential structural mechanical or electrical failures."

"Depends on competence of engineer."

"In fast-track work the number of changes in a project must be minimized to make probability livable fast-tracks are an impediment to implementation and require specific attention."

"I suspect that fast-track construction probably increases failure probability."

"We have experienced no difficulties related to fast-track arrangements. Requires continuous control and communications between engineer and builder."

"Depends on qualifications of design team and the contractor."

"In the process of design many changes are made. The structure is built first and before designs are completed in fast-tracking so the architect and other engineers need revisions. Because it is fast no one waits for the right answer. The structural engineer either makes enemies by saying no or he compromises. And we all do need the next job."

c. Construction

"Fast-track is a misnomer. They make a good looking start but they don't finish any sooner. This again relieves the architect and engineer from doing a complete and thorough job."

"Should not effect the job if everyone does their job."

d. Construction manager

"Errors and omissions caused by lack of coordination among structural engineer and architect."

e. State and building code officials

"This fashion of scheduling puts the building department out on a limb. The designers and contractors on these particular jobs must be experienced and trustworthy to ensure quality and performance."

"Makes adequate plan checking more difficult."

f. Owners

"If all precautions, inspections, etc., were performed it would not affect performance, however, short cuts may influence complete analysis."

"There is a chance here of a problem in that speed can cause the overlooking of smaller details which could cause a future problem.

This also produces the thought that speed causes decisions to be made without full refinement and that we may take a larger section to be safe, rather than take the time to refine the design, thereby increasing cost."

"Fast-track scheduling means a tight schedule which may increase propensity for error in design (or construction) which could lead to a failure. Fast-track projects are inherently complex, require greater communications and must be managed closely."

"What is a change control board?"

"This should not have any affect if the construction manager is doing his job properly. However, as a practical matter, there probably would be a slight increase in the probability of structural failure as fast-track scheduling tends to exert strong pressure on everyone to get the job done quickly."

"No experience in fast-track scheduling."

"Fast-track schedules may not allow adequate time for review and independent checking."

"No effect."

"I have no experience with fast-track scheduling but probably field changes might not be checked because of delay time on the schedule."

"Would tend to increase possibility of error by its very nature. Purdue does not fast-track."

g. Developer

No responses.

h. Banks and Financial Institutions

"Depends on GC."

i. Insurance Companies

"Assuming that a project has been adequately planned, we do not see that "fast-track" scheduling should have any affect whatsoever on structural failures, and should result only in better coordination and scheduling for work to be performed."

"The term fast-track need not connotate carelessness. The controls can all be in place."

"Could increase probability if all parties involved do not cooperate to assure that checks remain and margins of safety are acceptable."

19. SELECTION OF ARCHITECTS AND ENGINEERS

How should architects be selected for a project? How should engineers be selected?

a. Architects

"In good economic times when work is plentiful, we believe the low bid process is probably adequate. In bad economic times when there is little work, there is a distinct gamble on the part of Contractors and attempts at cost cutting become the rule rather than the exception. In England, we understand that they average the high and low bidders and award to the Contractor nearest the average."

"I qualify this answer by stating that the architect—engineer should strongly recommend to a client when the 'low bid' is *much* lower than the next 2 or 3 . . . that problems could be coming. Obviously, the

low man could have made an error. This should be *carefully* evaluated prior to accepting the *low* bid, or both the contractor and owner may lose in the long run."

"It depends on how low the low bid is. Award of a contract to the low bidder should not give rise to failures provided all contractors on the bidder list are pre-qualified and that the bid of the low bidder is not way out of line compared to the second or third bidder indicating the possibility of something having been overlooked. Where the low bid is way out of line and the contractor is apt to lose, he may want to cut corners thereby affecting quality."

"In the 32 years of practice in this firm which was founded in 1950, it has been proven over and over that an architect/engineer should be chosen on his merits, past performance and experience."

"Our firm has always presented credentials to the client based on our past record and the high quality of professionals and skilled (no-degree) personnel on our staff. We feel we are selected based on merit, performance and experience."

b. Engineers

"There is considerable evidence that the quality of work would be improved if more than price were the basis for contractor selection. It is true in buying a suit of clothes or an automobile and it is true in buying a structure."

"Often the lowest bidder is unqualified (he wants to get into the game and is willing to gamble), or he made an honest error. In either case the low bidder is looking for ways to short cut the work."

"Assuming adequate plan preparation and quality control of construction, the low bid procedure probably results in least cost construction. Contractors should not be permitted to bid unless they are pre-qualified based on past performance and financial stability. Considering these, there is no increase in the likelihood of failure in selecting contractors on the basis of low bid."

"Contractors will cut corners regardless of how much profit they make."

"This is a traditional workable approach. So long as the necessary controls are employed it will continue to be so. One must remember that even the vehicles that put a man on the moon were provided by the low bidder."

"There is no evidence available that a 'low bid' award will increase the chances of a structural failure. However, selection may be made from the lowest three bidders based on past performance."

"Depends on contractor (builder). 'Cost plus' jobs would prevent corner cutting in most instances."

"Through the decades, low bid awards have given rise to the change order and reduced contractor responsibility and reliability. Quality contractors can hardly compete with lawyer-owned 'Broker Contractors' who search the bid documents for loopholes and omissions. Our suggestion is to select contractor on same basis (process) as I proposed for professional selection—Please see answer to question 7, page 3. Competence, ability, understanding of project goals and objectives, etc."

"It should not if the plans are high quality and if the engineer doing the construction inspection does a first class job."

"Open bidding is a problem because one simply is reluctant to reject bidders. I believe in bidding by selected bidder's lists for their track record, etc."

"I am convinced that selection of low bidders is the single highest contributor to failures. Not only low bid contractors but also low bid designers."

"Proper selection of the building team is essential, both in design and construction."

"In some instances, low bid contractors can increase the likelihood of failure. In difficult economic times, even reputable contractors sometimes take projects at below cost. Either the contractor must shave money out of the construction process or pursue every opportunity to create change orders or extra compensation."

"The best approach is to use a selected bidders list. If you don't want them, don't let them bid. Government then becomes stuck with all the contractors that no one else wants."

c. Construction firms

"Prequality the bidders and then take the lowest—with a bond."

"Again, the designer should be doing his job—low bid is just fine."

"No, only the pressures by today's economy."

"Select list of qualified bidders (experience and financial ability)."

d. Construction managers

"You wouldn't hire a doctor to cure cancer because he was "low bid". Neither should buildings be constructed that way."

"Qualified subcontractor and certainly and are likely to put in good low bids. Past performance should be investigated."

"Competitive bidding for professional people has never offered quality services."

"Low dollar usually buys incompetence."

e. State and building code officials

"Far too many times a firm that is in need of work will submit a "low bid" for the purposes of surviving. If this occurs, then corners are definitely going to be cut and the probability of a structural failure becomes eminent."

"Award to the lowest responsible bidder."

"Throw out low and high bids—average remainder—award to closest to average."

"Does low bid contractor selection increase the likelihood of a structural failure? In most cases this is not true. Throw out low and high bid average the others and select on basis of closest to the average. While this is not likely to happen, consideration should be given to past performance."

"The A/E would still have the final responsibility for structural design and quality control."

"The initial process should involve the firm's experience, certainly past performance must be considered. Once the best qualified firm is selected, negotiation should be held on fee."

"Potential architects and engineers are interviewed and selected with all factors considered. Low bid may not be considered best, depending on project detail required, research and complexity."

"This is a difficult question to answer since any selection based on past performance is restrictive, similarly based on experience only is also restrictive. Competitive bidding and direct negotiation taken into account the experience and previous performance of the principals based upon the scope of work involved. This has to be a judgment factor by the owner."

"Generally speaking, the answer is no; however, the individual and his capability is more important than the title given to the function."

"I feel that a project should not cause a professional that often represents less than 8 percent the cost of construction to be placed in simple competitive bid situation. Enough monetary support must be available to insure proper structural design and follow-up during construction."

"The selection of an architect should be based on three factors: 1. His fee proposal, 2. Experience, and 3. Previous performance. Each factor should be considered in his selection. The engineer is usually selected by the architect. The state requests that we be informed as to who he intends to use. If our past experience with that engineer is satisfactory, we do not object."

"The 'low bidder' is not always a professional. Experience and past performance speak for themselves."

f. Owners

"Not a very good criteria. Selecting one from lowest three bidders may or may not improve situation. Past performance may be a guide but not to be used as only criteria."

"Enforcement of restricting the bidders list to qualified bidders and of retaining the right to reject any/or all bids."

"We feel that low bid construction is the only viable path and we do not believe that it contributes to structural failure if adequate measures are provided in the bid documents to assure a structure will be built to a proper specification."

"Cannot correct this problem through the bidding process. Must have good design and thorough construction inspection and administration."

"Government procedure is to award to the lowest, responsive, responsible bidder."

"Pre-qualify bidders based on experience, bonding capacity, credentials of lay personnel, claims for faulty work and other criteria as necessary. Then the lowest bid will almost always be the best bid, absent errors in bid computation."

"Low bid contractor must comply with contract documents."

"A low bid contractor should not increase the likelihood of a structural failure provided the plans and specifications are adequate and the work is inspected and tested by persons not affiliated with the contractor."

"Low bid is not the only qualification for selecting a contractor. Other requirements in contractual, financial, technical areas and past performance play equal part in selecting a contractor."

"Use only qualified experienced design firms (establish reasonable criteria). Eliminate those firms with a history of design failure. These don't usually happen overnight."

"All of the Washington Metropolitan Area Transit Authority architects and engineers are selected on basis of their qualifications and past experience."

"Cost has to be a factor in selecting architects and engineers, but the choice should certainly not be based on a straight competitive bid. There is a wide range in the quality of these services that should be reflected in the selection process."

"There are a number of other factors which also should be considered in the evaluation, but these are two of the more important ones."

"What happened to Direct Negotiation for Engineers?"

g. Developer

"Not if prequalified."

h. Banks and financial institutions

"There is nothing wrong with the low bid process as long as the specified and required tests are done. The project Architect and Owner/Developer need to qualify any and all engineers used in a design/build situation."

"Owner's rep is there to watch out for these things, we assume he's doing his job."

"A low bid contractor selection should be made only after the contractor is qualified in all respects for the specific type of project bid."

i. Insurance companies

"Need to take into account project design, size and complexity."

"In certain instances, such as special purpose structure or fast track or in a special building such as corporate headquarters, price should not be the key selection criteria."

"Responsible for selecting and recommending engineers to the property owner. The owner of a to be built project considers, among other items of qualification, all of the mentioned selection criteria."

"A combination of experience and performance should be taken into account leading to direct negotiation. Engineers selection should have architect's approval if architect doesn't make direct selection."

20. SELECTION OF CONSTRUCTION CONTRACTORS

Does "low bid" contractor selection increase the likelihood of a structural failure? What form of bidding would be fair and more effective? How can unqualified firms be eliminated from competition on Federal government projects?

a. Architects

"Require past experience in projects of equal size and magnitude . . . and listen to the recommendations of the architect/engineer selected."

"Prequalification is the most direct and practical approach to maintain control and avoid failures."

"Insist on bonding company information for immediate past projects. It is difficult to do. We have, in the past, asked firms *not* to bid. Sometimes it works depending on our past bad experience with them."

b. Engineers

"A broad question requiring considerable thought. First step is by eliminating the pressure for competitive bidding."

"Qualification of the contractor must be done well in advance of the invitation to bid. It would be preferable to only allow prequalified contractors to bid as is done by large private owners/developers. Qualification must also mean more than just financial adequacy."

"Establishing qualifications in the IFB or prequalifying bidders could both be effective for construction. Both might require changes in current law. If the question related to design firms, the vehicle already exists through the Brooks Selection Act, since only qualified firms will be short-listed for possible negotiation of fee."

"By establishing and defining the qualifications in the invitation to bid, unqualified firms can be eliminated from the competition. Federal laws can also be changed to disqualify such firms."

"Prequalification for work can be as stringent as necessary to eliminate the unqualified."

"Author explicit, uncomplicated RFP's. Evaluate responses objectively, rating in terms of relevant experience, staffing, workload, presentation of credentials, interview of past clients, visual evaluation of proposer's physical space, staff, operating condition, etc. Change Federal law to provide monies for preliminary solutions to project as part of proposal response as part of 'How to best do the work.' "

"By going to a qualified firm and negotiating the engineering services."

"Simply put, the owner must take the responsibility for selection of qualified professionals. I believe that selected committees of peer professionals do this best."

"I advocate the prequalification concept."

"Selection of the firm should be based on a number of criteria. Two of the most important criteria should be past performance and experience."

"It is doubtful there is any way to eliminate unqualified firms. Most methods would merely discriminate against younger firms in favor of the older, entrenched firms."

c. Construction firms

"I don't feel that in the case of general contractors that they can be eliminated, however, I think they can be reduced by the establishment of qualifications beyond the ability to produce a bid and performance bond."

"By prequalifying."

d. Construction manager

"Through intelligent exploratory interview process."

e. State and building code officials

"Very difficult to do."

"Highly supportive to this recommendation."

"Less paperwork and politics. More based on technical ability."

"Require that state licensing requirements be met."

f. Owners

"Caltrans basically awards to the low bidder who can obtain a performance bond. Efforts to prequalify contractor on the basis of past performance or experience have been abandoned. For private work, limiting bidders to those firms with good track records should reduce the probability of failures."

"It's entirely possible that a low bid contractor could attempt to recover from a low estimate by skimping in some areas, thereby leading to a failure of some type. However, the government inspection process should prevent this from happening."

"The low bid contractor does not increase the likelihood of a structural failure since all materials, fabricated members, shop drawings and the installation of structural member must be approved by the Authority's team of material inspection division, structural designers and field inspectors and the contractor must still conform to the specifications."

"If the contractor is qualified, the "quality" of the design should not vary."

"Review of qualifications of firms by engineers of the profession."

"The West Virginia Department of Highways has a prequalification procedure which requires a contractor to be approved prior to submitting a bid. This is based on prior experience, technical ability and adequate financing. We are not aware of Federal law."

"There is a need to improve the quality of firms on Government projects and prequalification is a step in the right direction."

"Prequalifying will help. No iron-clad method exists, however."

"Prequalifying contractors."

"Disqualification will have to be supported by very sound evidence to withstand the legal challenges that are sure to come."

"I don't think this is the problem."

g. Developer

"It would be difficult due to the discrimination factor."

h. Banks and financial institutions

"Firms with repeated poor past performance with the government or private sector should not be allowed any government contracts for a specified number of years."

"Require adequate bid bonding and evaluate prior performance prior to establishing bid lists."

21. NEED FOR LEGISLATIVE CHANGES; LOCAL, STATE OR FEDERAL

Do you see any need for legislative changes at either local, state or Federal levels which would enhance the safety of structures?

a. Architects

"Because of the legal atmosphere in which Architects and Engineers are required to practice today, there is an unrealistic amount of time and expense being devoted to loss prevention and legal defense which is not justified and seriously impacts the amount of time which could be allocated to design functions. Consequently, we feel there is a drastic need for legislation which would create a Federal "accountability law," which if possible, would require mandatory adoption by all states. The construction of the "accountability law" should be such that it embraces the following conditions:

(a) That any party or parties who believe he or she has been damaged by another party or parties is entitled to his day in court, providing such claim or claims are made within a reasonable time after the damage has been discovered or reasonably should have been discovered as prescribed in applicable laws relating to statutes of limitation.

(b) The complaining party or parties will be held accountable for having satisfied himself or herself that on the basis of prior research of applicable documentation, including contract obligations, applicable laws or such other pertinent information, that the parties named as defendants have not performed within reasonable industry standards or are otherwise liable for damages which have been sustained by the complaining party.

(c) If the court or other duly constituted legal body finds for the complaining party against one or more of the defendants, then he or she is entitled to such relief as the court or other legal body may find appropriate based on the evidence presented. If, on the other hand, the court or legal body finds any or all of the defendants harmless in the charges filed against them, then the complaining party will further be held accountable to any and all such defendants to reimburse them for all direct personal expense, loss of revenue, legal fees, miscellaneous expense, court cost, etc., incurred in the defense of said claims.

In recent years, there has been a progressive attempt to make the Architect the guarantor of the Contractor's work and the indemnitor of the Owner, both Government and private, of any and all claims which may arise out of their association with a given project. There is a further attitude that Architects have ascended above the level of human frailty and are expected to be perfect in all of their endeavors. These attitudes are ridiculous in concept as they can only result in the establishment of confusion with respect to true accountability. Obviously, the Architect cannot guarantee the Contractor's work as he has no Contract with him and no power to make him perform. To assert such a responsibility has the effect of weakening the Owner's position against the Contractor by the splintering of clear-cut accountability. The guarantee and indemnity aspects are an obvious attempt to find a fall guy, and the Architect is the prime candidate.

To illustrate the point, we refer to a specific General Statute in the State of North Carolina, G.S. 133–1.1(b) which reads as follows: "On all projects requiring the services of an Architect or Engineer, or both, the Architect or Engineer or both whose names and seals appear on plans or specifications, shall inspect the construction, or repairs or installation, and based upon said inspections shall issue a signed and sealed Certificate of Compliance to the awarding authority that the Contractor has fulfilled all obligations of such plans, specifications, and Contract. No Certificate of Compliance shall be issued until the Architect and/or Engineer is satisfied that the Contractor has fulfilled all obligations of such plans, specifications, and Contract.

This statute has been on the books for some years but in the past has not been literally interpreted by State agencies. It has been the practice of the design profession to issue certifications using qualifying language more in keeping with services contracted for which has been accepted by State agencies. An example follows:

On the basis of our periodic observations and inspections, we certify that, to the best of our knowledge and belief, the Contractor has completed the Project in accordance with plans, specifications, and Contract.

Now we are informed that they will expect conformance to the letter of the law. An analysis of the situation produces the following logical conclusions:

(a) In the first instance the law was unreasonable in concept and was obviously authored by persons who are totally unfamiliar with the practice of Architecture and Engineering. It has been the practice under State Contracts for generations to provide periodic review and inspection of construction projects, generally averaging one day a week. Under this normal and usual approach it is absolutely impossible for a design professional to certify that "The Contractor has fulfilled *all* obligations of such plans, specifications, and Contract," with any degree of certainty.

In the case of some large projects the State may authorize the employment of a full-time construction representative to be employed by the Designer, but even under these circumstances it would remain virtually impossible to make such certifications. The reason is that a large project could very well require the employment of upward of 250 construction workers at a given point in time involved in 20 to 50 separate disciplines or building systems. There are 480 minutes in an 8-hour day, and if the construction representative had nothing to do but walk around and watch all the workmen on the job, he would be able to spend less than 2 minutes a day observing each construction employee's work, if we assume there are 250 employees on the project at a given point in time. What is happening with a given employee during the remaining 478 minutes is anybody's guess.

(b) The State Contract specifically states that the Architect is not required to guarantee the Contractor's work. Yet a Certificate specifically complying with this statute would, in fact, imply a guarantee of a Contractor's work.

(c) If a Design Professional should provide such a Certificate, what are the ramifications:

(1) He is providing an implied warranty and is in effect guaranteeing the Contractor's performance. Under such circumstances he becomes:

a. Responsible for the Contractor's work and his obligations.

b. Guilty of fraudulent misrepresentation as he cannot, in and of his own knowledge, know for sure that the Contractor has performed in total compliance with the requirements of drawings and specifications.

c. Uninsured as his professional liability insurance coverage specifically excludes coverage where an Architect or Engineer guarantees a third party's work. This is equally as bad for the client as it is for the Designer, since the purpose of professional liability insurance originally was to cover those catastrophic errors, which even the most professional of humans can sometimes make. I would venture to say that there is not one Architectural firm in the state who could pay off a million dollar loss from accumulated assets and cash flow from his operation. There is simply not that kind of profit in the business, and without insurance protection, the client could well become the big loser monetarily.

(2) Fraud is a crime which can result not only in actual damages, but in punitive damages which generally run from unreasonable to ridiculous sums of money. Failure to conform to Chapter 133, if found guilty, constitutes a misdemeanor punishable by loss

of license for a period of one year and a fine of not more than $500. As distasteful as the loss of license appears, it is, in my judgment, the lesser of two evils. If a Design Professional were found guilty of fraud, he would also lose his license and perhaps everything else he spent his life accumulating.

(3) Paragraph 133–1.1(b), in the last sentence provides an escape hatch to providing such a Certificate and states, "no Certificate of Compliance shall be issued until the Architect and/or Engineer is satisfied that the Contractor has fulfilled all obligations of such plans, specifications, and Contract." Since he cannot possibly see all of the Contractor's work, and he can never be truly satisfied that the Contractor has fulfilled all obligations. He can within the framework of the law, refuse to issue such a Certificate. However, subparagraph (f) provides that "neither the Designer nor the Contractor involved shall receive his final payment until the required Certificate of Compliance shall have been received by the awarding authority." As a practical matter, if this paragraph were to be enforced, it is better to lose a little than to risk losing everything.

(d) It would appear to me that this law is designed to entrap the Design Professional. If he provides a Certificate as stipulated in this statute, he is guilty of fraudulently misrepresenting his knowledge of fact by impliedly guaranteeing that the Contractor has performed his work totally in conformance with the Contract Documents. If he fails to issue a Certificate strictly complying with this statute, he can be guilty of a misdemeanor. In other words, it is a law of entrapment and as such, in my opinion, is unconstitutional.

It becomes fairly obvious that for the Design Professional to truly be able to make certifications, as contained in this statute, it would be necessary to fully duplicate the supervisory personnel of every Prime Contractor, Subcontractor, Sub-subcontractor, etc. Every crew has a chief, multiple crews have an Assistant Superintendent, Contractors have Superintendents, Engineers, General Superintendents and Project Managers. What a waste of manpower in a nation which is coming out second best in the world market simply because we can no longer efficiently and effectively produce.

Under present law and established legal procedures, in our experience and knowledge, many law suits are filed without any realistic basis purely on the premise that they can involve multiple parties and ultimately effect a settlement. Because it is less expensive for the defendants, than pursuing it through the courts where there is no legal recourse or relief to recover their cost if found innocent, the cost effective decision for settlement is, therefore, mandated rather than the seeking of justice. In a word, current laws and procedures sanction and, in fact, encourage legal blackmail and/or extortion. We do not consider this to be "justice for all" but rather a disgrace to the American people and all this country pretends to stand for. To injure one or multiple parties in the name of justice for a complaining party is not true justice by any definition. True justice would demand accountability on the part of all parties in a dispute. If this is not true, then the inscription on the Supreme Court Building, "Equal Justice for All", should be removed.

We are aware that there is legislation before Congress which, if passed, would help Architects pay for defending professional claims. While we strongly urge your support in this legislation, as it is sorely needed, it would certainly not provide the kind of assistance in ridding this country of the injustices which now exist as would a true accountability law. With such a law, we believe the frivolous and unwarranted suits would be drastically diminished once the price tag for frivolity is established."

"Maintain registration of architects and engineers. This talk of dropping registration is ridiculous. Also, registration should be recognized nationwide rather than statewide."

"Take away the requirement for submission of price proposals for architect/engineering services. Determine qualifications by other than fee."

"Legislation may not be the best path, but a procedure should be encouraged by which any question of safety or quality in the structure should be reviewed by an independant testing laboratory with the expense allocated in a fair manner."

b. Engineers

"Legislation in any form is not the answer. The profession needs legislative support in letting professional processes work."

"Have no specific legislative changes to suggest. However, better enforcement of existing legislation would help."

"Require a Structural Engineer Certification on all projects, not just an Architect."

"Better licensing of structural engineers would enhance the safety of structures. Current laws on registration should require training in structural failures. Existing laws could also be better enforced."

"Hold the professional responsible by paying him, giving him time to do the job and make sure the design engineer is included in the construction phase."

"States have boards for testing and licensing professional engineers. This license may be, and sometimes is, cancelled when incompetence or negligence is demonstrated. There should be a requirement that licensed professional engineers not only be responsible, but actively participate in design and construction procedures where the safety of workers and future users is involved."

"We need a Federal statute requiring structural, electrical, and mechanical engineers to inspect and certify that all materials, fabrication, and construction conform to their project plans and specs. We need a Federal statute requiring all plans and specs to conform to a state, local, or model building code. We need a Federal statute requiring a second set of structural, electrical, and mechanical engineers to certify that the plans and specs conform to the appropriate building code."

"Providing for professional design firms to exercise their expertise should enhance the safety of structures and center responsibility for public safety. This was the original intent of registration laws which have lost their effectiveness through excess Federal intervention."

"Code enforcement should be mandated. All projects should be designed by qualified, experienced and registered consultants. All projects should be inspected by qualified personnel during construction. Update building codes to keep pace with evolving new technology."

"Need to see that responsibilities are spelled out and then followed through each step of design and construction. In most locales, this would not involve law changes. Require licensed structural engineer, not an architect or civil engineer, to design structures, particularly in public buildings."

"Eucouragements for excellence, high quality, skills, competence and consistently superior performance rather than low-bid. Rate performance on completed project costs (including all change orders). License contractors according to class of building they are qualified to build—re-examine (renew) regularly based on current staff. Laws/ building codes at all levels should be more specific regarding inspection requirements."

"From a list of prequalified consultants, select one qualified engineer for negotiation. Eliminate price competition with engineers. The practices of elaborate selection procedures and price competition, low engineering standards, does not result in best designs, causes undue delays, requires more supervision and costs the taxpayer more money."

"Building code improvement by establishing state codes and appropriate legislation to enforce them—at local level. These codes can define the roll of professionals for all size projects, and field Q.C. as well."

"I think the Brooks law should be widely and stringently enforced to assure that competent designers are properly selected for Federal projects. I can cite repeated examples where Federal agencies have gone to great length to circumvent the requirements of that statute. Similar requirements regarding designer selection based on qualifications must be employed on local and state levels. The low bid method of employing designers and builders must be abolished."

"Careful enforcement of the existing codes would most likely be sufficient except in the case of structures such as earth dams where building codes are not particularly applicable."

"Place a more strict liability on the owner of any building used for public occupancy. Then he is responsible and will use more care in what he buys and operates."

c. Construction firms

"Don't try to legislate."

"Simplify codes and assign responsibility to designers."

"Less government the better—laws exist (State) for registration of contractors, engineers, architects, etc. The only change may be re: inspection—too many hands are out by incompetent inspectors."

d. Construction manager

"Need to assist as opposed to hinder or complicable process."

e. State and building code officials

"The low bid with no prequalifications has allowed too many unqualified contractors to bid, particularly in poor economic climates."

"Changes have to first come from the voluntary consensus writing groups then could be adopted by reference by either local, state or Federal agencies."

"At this time there are no restrictions or state regulations of any kind in Texas."

"Place code enforcement on a higher professional level, increase responsibility, for compliance, on the private sector level, involve li-

censed professional designers more in plan preparation, and increase enforcement authority of building departments."

"Legislation in Idaho currently makes enforcement totally optional for city and county governments."

"Jurisdictions need more funding to make practical, necessary inspections. Given that the public benefits from all code enforcement, general funds as well as user fees might be used to finance building departments."

"Stricter state licensing laws for architects, engineers and contractors."

"Cost would far outweigh benefits the existing regulatory system keeps these occurrences with acceptable limits."

"States that adopt building codes should be state statute update on a regular basis."

"A complete National Building, Plumbing, Mechanical, Fire and Safety Uniform Code. Similar to the N.E.C. National Electric Code in use presently nationwide."

"Considering underlying conditions at the local level it would be best if all legislative changes or laws could be enacted at this level with reference to broad national standards. Local legislative bodies do not always have the expertise to do this. In this case the state would be best to work with local government to develop these standards."

"Uniform Certification Program should be developed and mandated for all Federal, state, and local building officials."

f. Owners

"Not at this time in Nebraska."

"From the aspect of the West Virginia Department of Highways, we see no need for legislative changes."

"Review and update code and quality control requirements. Due to increased regulations, i.e., OSHA, Environmental, Architectural Barriers Act, etc., design requirements and effort have increased. Therefore, delete or raise the 6% design fee limitation for Federal contracts, which has been in effect for many years, in order to reimburse for required effort on complex projects."

"Require building officials to possess the same skills level as those who are being regulated (e.g., architects and engineers). In reality, this will be impossible, but it deserves consideration. MOST IMPORTANT! Require mandatory inspection of construction by a registered design professional when the prevailing law calls for the project documents to be prepared by a design professional."

"The establishment of qualifications of a contractor in the building."

"Structural safety should be the professional responsibility of the architects, engineers, contractors, fabricators and inspectors."

"Building codes and require Resident Engineer."

"Local building department, with adequate staff can enhance the safety of structures."

"I question the effectiveness of reducing failures by legislating additional controls. Failures that I am familiar with have resulted from poor details, erroneous structural analysis, bad construction practices or faulty materials."

"Legislation should reflect reality. Testimony should be heard from experts from the daily firing line rather than the academic experts that Congress always bases their actions upon."

"To require the Contractors superintendent of construction to be a licensed professional Engineer or one with a qualified experienced background."

"The various levels of government should require work under their jurisdiction to be certified by those concerned with design and construction. Design work should be certified as to having been reviewed and checked by another designer. Construction work should be certified as specified by drawings and specifications. All changes in field should be certified by a qualified designer."

"Legislation does not provide for integrity."

g. Developer

"Complete review of all structural failures. Their cause and how could they have been avoided."

h. Banks and financial institutions

"Require sign-off by public official (C/O) for all buildings."

"Local building departments in some areas need to upgrade staff and require testing lab inspections. To be more effective, building departments need to take responsibility for their actions."

i. Insurance companies

"Laws which require proper engineering supervision and certification by engineers. This supervision is only ¼% of the construction contract cost, but most owners do not wish to pay for it. They do not seem to mind problems one year later due to poor Q.C."

"I don't feel legislation accomplishes what it sets out to do."

"If structure unique or unusual (includes not only buildings but tanks, silos, etc.) there should be follow-up by designer/structural rep."

"Possibly in the area of continuing education in specific areas of construction technique."

"It should be done promptly and by upgrading codes and by not cutting fees to the bare minimum."

"On a Federal level, require independent review of all structural items which impact upon the integrity and safety of all developments."

"Consideration should be given to a uniform National building code. So many of the major design firms design projects in a number of states. Our experience has been an architect from Missouri, an engineer from New York, and other consultants from other states. In each case it has been necessary to acquaint the parties involved with the building codes in force in this particular region. It seems to me that a uniform code would reduce the chances of errors and omissions and greatly enhance the quality and safety of structures, of course, provided the codes are written with this objective in mind."

"No more federal regulations or regulators!!!"

22. ROLE OF A NATIONAL BOARD TO INVESTIGATE STRUCTURAL FAILURES

The National Transportation Safety Board is recognized as a professional body which investigates aircraft accidents. Their work is widely respected and they disseminate accident reports throughout the aircraft industry so that aircraft owners, pilots, controllers, etc., can stay current and be more sensitive to the causes of accidents? How

would you feel if a respected body of professional people from the building industry were to perform a similar function?

a. Architects

"We, and we believe all responsible design professionals, would welcome the dissemination of failure reports so long as they are factually based, rather than being based on the opinion or opinions of so-called experts. After all, in the course of human endeavor, the greatest advancements for mankind have generally come about through the lessons learned by trial and error. Certainly, the knowledge gained through the collective dissemination of the causes of failure could be an invaluable continuing educational tool for the design profession and we would heartily endorse it."

"I think this a *good* thing. Major accidents should be investigated and the reports should be made public so that all of us can learn from our own mistakes."

"Excellent! I'd be pleased to serve."

"Failures experienced in the construction industry are so varied as compared to those in the aircraft industry that creation of such a permanent body would not serve the industry well, instead it would create a great deal of controversy and problems."

"At present, in case of a failure, a similar approach is followed a group of qualified, experienced professionals is slected to investigate and present their findings. The findings are then published in technical magazines, periodicals and newspapers that are available to those associated with the construction industry."

"Having a permanent Board, as compared to the present practice, would not improve or correct the problem."

"In my opinion we do not need another investigation board which is not qualified to investigate accidents. Some engineers are competent in the larger, complex spans, space frame, monster high-rises and some are competent in analyzing the smaller failures—each state should take care of its own failures through the engineering and architectural professions. A model accident board format could be addressed by Federal and state."

b. Engineers

"Such reviews are now a part of professional processes. Professional liability insurance companies, in collaboration with professional societies, universities and various boards and foundations, lead this effect."

"It is too difficult to form an opinion without a better description of the function of this proposed organization."

"Do not know if this would be feasible—how many building accidents occur? How large an accident or type would they investigate? Could go either way be helpful or not be."

"We would welcome such a body, but do not believe they should be charged with reviewing codes."

"Not necessary. The courts now determine who's liable. This body would not have any powers. Each structural design is an entity in itself."

"NTSB is not restricted to aircraft accidents. They also review other transportation facility failures (e.g. bridges). A similar board for building failure investigation could be helpful."

"The design profession certainly does not require another Federal entity to contend with. As pointed out throughout the above comments, it should be recognized as a true profession and be permitted to operate as such."

"It is imperative that all accidents are investigated by a team of experienced professional people and their findings are made available to the design professional. At the present time, this data is woefully lacking in spite of many investigations that have taken place. It is high time that failure investigation reports are made available to all from a central source."

"Such a board would serve to consolidate the various effects of investigation teams that are formed after every major structural failure."

"If this body were a totally objective, professional, truth seeking group, this would be wonderful. In addition, their findings should be publicized in a discipline information format, giving rise to the elevation of professional standards. It should be impersonal."

"In the highway field, this is a role that has been assigned to FHWA."

"Excellent idea."

"I support such a board, not necessarily constituted by the Federal government. The American Society of Civil Engineers is currently studying failures and methods to obviate them. One problem that needs to be addressed is the lack of information regarding failures that is available to the nation's designers. Once a failure occurs, the available information is usually supressed by attorneys until all claims are settled. Thus, it is difficult for designers to learn from past mistakes of others."

"Although it would be valuable to review failures, the liability and insurance problems associated with design and construction would likely become unbearable."

c. Construction firms

"This might be a good idea if it didn't get out of hand and take too long for its report."

"All or part of these could be assigned to any special body convened."

"Good idea."

"The establishment of this type of board could be effective in reducing structural failures only if this board was composed of various disciplines from all aspects of the construction industry and would be used in only cases of catastrophic structural failure. The purpose of the board should be to investigate the cause of the failure and disseminate the information gained by the investigation. Its purpose should be to reduce the amount of litigation now experienced during every major structural failure in trying to lay blame on all the parties involved like most NTSB investigations. I feel that most investigations would prove human error which we cannot ever eliminate, however, the source of that human error should be determined as inexpensively as possible."

"Whenever we hear of a structural failure during or after completion we await the very detailed reports published in Engineering News Record. They seem to be able to penetrate directly to the cause without being hampered by formal hearings, or other means of obscuring the responsibility."

"Good idea. State level."

"Good idea. Also serve as final authority. Now, 15 different groups (some with special interests) investigate."

d. Construction managers

"All of these would benefit the construction industry."

"I don't believe that Federal government boards or committees can control structural failures any better than the courts have been doing. A national registration board for structural engineers to provide examination for certification for registered professional engineers would provide the best control of structural failures."

e. State and building code officials

"I think we already have this type of service with the professional societies and registration laws and building codes. Research and distribution through and by the Bureau of Standards could result in more updated information available to designers and engineers."

"Unquestionably there is a need for such a body."

"I would support such a board."

"As long as they were from a private sector and governmentally influenced."

"Excellent idea and should be developed. The dissemination of information to all in and associated with the building industry should be viewed as a top priority."

"Good idea. Probably the National Bureau of Standards could do the job."

"NCSBCS is currently performing similar functions on a limited scale with some merit. NCSBCS-National Conference of States on Building Codes and Standards."

"This would be a step in the right direction, providing the bond does not have vested rights."

"All of the listed items should be included in State or Federal Construction Safety Boards with authority to impose penalties."

"Very good idea, but, how would such a board be funded?"

"A safety board for buildings could perform all of the functions listed; however, their role should be limited to investigation and specific recommendations."

f. Owners

"If properly selected and given authority to enforce findings a board of this type would have great merit."

"This could possibly be done but the development of it would be very difficult."

"West Virginia was involved several years ago with a structural failure, the Silver Bridge collapse, which was investigated by the NTSB. The investigation was in-depth and did discover a new failure mechanism. We would feel at ease with any investigation which would improve our design or construction techniques."

"A similar body for the building industry may be useful but they should investigate building failures, not accidents."

"Such a Board would be effective only if composed of professionals actually involved in the design and construction of major facilities. Should not be a government board or purely academic, but should have members from government, private engineers and the academic arena."

"It might be helpful, but probably not. Unless the Federal government wants to get involved in the process of regulating building con-

struction in the same manner that it regulates and inspects aircraft, then there is no basis for comparison. Many private and public agencies are now involved in building the disaster analysis process. Further involvement by the Federal government just for purposes of analysis would add little to what is presently available."

"This will be more beneficial than more legislation. This group of professionals could investigate, report and recommend changes in codes or design criteria."

"National Bureau of Standard could be assigned to the task in an advisory role."

"A major problem is that timely dissemination of information concerning failures is constrained because of the effect it may have on litigation. A way to remove this roadblock would be very helpful."

"Anything more than dissemination of information would not be cost-effective; qualify design professionals and let them perform."

"In light of the numerous professional societies currently existing and the registration requirements within the states, another governmental agency may not be necessary."

"A very good idea."

"Good idea, as long as "respected" also means competent."

g. Developer

"This would be good."

h. Banks and financial institutions

"Good idea but our litigous society may make this difficult to do. Dissemination of this information prior to adjudication of civil/criminal matters related to collapses could cause problems."

"Could be beneficial if the implementation is not contradictory to the previous question (meaning: not requiring legislative changes)."

"Private organizations already perform most of these functions. I feel that the data received as a result of studying recent failures will help control future problems of a similar nature."

i. Insurance companies

"It would be interesting as well as informative if there were a central clearinghouse through which all building structural failures might be examined, analyzed and reports made available, however, this might be extremely difficult to accomplish considering that each major structure is usually one of a kind and it would be hard to determine at what point such failures would cease to be examined with respects to size of the project."

"I doubt that it could be done due to the number of structures in the country."

"Industry and states normally do thorough investigations after the fact. Any number of 1978–1982 failures will demonstrate this."

"National Bureau of Standards has done a good job on recent structural failures."

"This would be a Federal duplication of a local government function. Better results could be obtained by private, state and local investigations. The best method of monitoring the industry is for the initiation, practice and acceptance of the "UL" label and "National Electric Code" type of system for the other disciplines (i.e., structural, glass, energy conservation, etc.)."

"All, a good idea."

Appendix C.—Listing of Selected Structural Failures

State Office Building (Hauppague, New York): Window wall blew out; aluminum mullions and glass peeled off.

Johnny Creek Dam (near Fort Payne, Alabama): No laws governing dam design or construction; no inspection program.

Bearwallow Dam: Killed 4.

Kennedy Center (Washington, D.C.): $4.5 million to repair leaking roof; cracked concrete ceilings; buckled plaster; 150 leaks.

John Hancock Tower (Boston, Massachusetts): Windows fell out until June 1980.

I–79 Bridge (near Pittsburgh, Pennsylvania): Cracked girder; 2-inch wide crack in web of 11-foot deep section of steel plate girder.

Commodore John J. Barry Bridge (Chester, Pennsylvania to Bridgeport, New Jersey): Five years old in 1977 when cracks were found in reinforced concrete piers.

MGM Building (in New York City): 11 years old; in 1977, 7 panels broke loose during windy conditions, alternating suction and pressure.

County Courts Building (West Orange County, Westminster, California): Differential settlement.

Montreal Olympic Stadium (Montreal, Canada): 60,000 seats; steel beams slipped out of position; collapse prevented by repairs.

Toccoa Dam Failure (Georgia): 39 people killed at a Bible college.

Walnut Village Church of Christ (Garland, Texas): Roof collapse, May 21, 1978; 1 killed—9-year-old girl; 57 persons injured.

Indianapolis, Indiana: 30–50 percent of 4,000 windows in pyramid structure cracked and leaked.

U.S. Postal Service (Worcester, Massachusetts): Roof collapse.

C. W. Post College: Roof collapse; 171-foot diameter dome; 3500 seat auditorium.

City of Chicago Elevated Transit Line: 0.9 mile section; full-depth cracks in structure (box sections).

Corps of Engineers Report 9 Dams With Questionable Structural Quality: Lake-O-Springs, Shelby County, Alabama; Salisbury Mills, Orange County, New York; Warwick, Orange County, New York; Sherwood Forest Lake, Rankin County, Mississippi; Broadway Lake, Anderson County, South Carolina; Twin Lakes, No. 1, 2, and 3, Bledsoe County, Tennessee; (Unnamed) Claiborne County, Tennessee.

University of Massachusetts: 28-story Library Tower; brick facade fell off.

Veterans Memorial Arena (Binghamton County, New York): 1.5 acre space frame; cracks after 6 years.

Stadium Roof Collapse (Rosemont, Illinois): 288-foot span; 5 persons killed.

Four Lane Interstate 24 (across Ohio River Between Illinois and Kentuckv): Flaw in butt welds.

Twin Bridges Crossing the Kishwaukee River (Illinois) Failure: Concrete box girder; 5/8-inch crack.

Jenkins, Kentucky: 400,000 gallon water tank (steel) collapsed; one person killed; foundation washed out.

Hartford Civic Center (Hartford, Connecticut): Roof collapsed; design flaws suspected.

Nelson Rockefeller Mall: Nine marble clad buildings cracked and splintered in winter of 1978–79.

Water Tower Place (Chicago, Illinois): 6 panels fell out in April 1979.

Gimbels Department Store (New York, New York): 2 panels fell out late in 1978; 2 more fell in mid-1979.

Field House—1979 or 1980: $16 million; built for Lake Placid Olympics; horizontal truss needed strengthening; welds were redone, strengthening plates added.

Teton Dam (Idaho)—June 1976: Dam collapsed; 11 killed; flooded 300 square miles; loss of $400 million; erosion of impermeable core; failure in right abutment; downstream face inadequately drained; design not adapted to difficult site geology.

Crosby Memorial Kemper Arena (Kansas City, Missouri) June 1979: 17,600 seats; roof drains failed to carry water away in time to avoid overloading the roof structure causing collapse of roof; 42 roof connections redesigned and rebuilt. Eliminates bolted connections of the type that failed; dynamic loading allowed high strength bolts to decrease 20 percent of original load-carrying capacity.

Three Story "F" Building (University of Hawaii, Honolulu): Soil foundation problems caused cracking.

General Services Administration: 8 buildings with foundation problems—settlement of several inches.

Silver Memorial Bridge (West Virginia): U.S. 35 from Pt. Pleasant, West Virginia, to Gallipolis, Ohio; cracks in 16 welds.

Soldier Creek Dam (Utah): Strawberry River; Department of Interior funded the study as a result of the Teton Dam failure; Soldier Creek was found to have similar faults as Teton.

Plutonium Laboratory Complex (Lawrence Livermore Laboratory): Damage during January 1980 earthquake (5.6 magnitude Richter) was structurally significant; lab was not designed for a specific quake and current codes.

Hyatt Regency Hotel (Kansas City, Missouri): Collapse of pedestrian walkway with subsequent loss of life.

Moffitt Library at Berkeley (University of California): $4.2 million retrofit needed on Berkeley's newest and most heavily used building (completed in 1968).

Crude Oil Production Tower: Metal fatigue on 392-foot high tower; $35 million in damages claimed by Brazil. Collapsed September 7, 1980.

Washington Sewage Treatment Plant: Collapse of 300-foot wall section (20 feet high); $450 million plant.

VIII. MINORITY VIEWS

Report on Structural Failures in Public Facilities; Subcommittee on Investigations and Oversight

The minority is concerned over the damage and personal tragedies brought about by structural failures in the past, and recognize the need for a thorough review and analysis of this serious issue. We agree it is extremely important to determine the underlying causes of structural failures and to understand what role, if any, shortcomings in technology or engineering training played in these failures.

We take issue, however, with the timing of the report's release. The hearing upon which the report is based was held August 3 and 4, 1982, during the 97th Congress. Traditionally, and we think for good reason, subcommittee reports are issued in the same Congress in which the original hearings were held. This policy is a wise one, and is especially important in protecting the rights of the minority. To illustrate the problem, we would like to review our current situation on this report. First, none of the minority members who served on the subcommittee during the 97th Congress serve on the subcommittee in the current Congress. In addition, the minority counsel serving the minority members in the 97th Congress is no longer with the subcommittee. The result places minority members in the untenable position of approving a report without having benefit of participating in the hearing or benefiting from the advice of the minority staff serving the subcommittee at that time.

We are being asked, subsequently, to support the issuance of a report in an informational vacuum. Therefore, it is difficult to have a basis upon which to judge the merits of the report's recommendations. We strongly disagree with this process and feel it is inappropriate for this subcommittee.

Larry Winn, Jr.
Joe Skeen.
Claudine Schneider.
Alfred A. McCandless.

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